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of
WASHINGTON

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A CHECKLIST OF SPECIES OF *HELIOTHIS* OCHSENHEIMER (LEPIDOPTERA: NOCTUIDAE)

E. L. Todd

Abstract.—This cross-indexed list of 154 species-group names in *Heliothis* Ochsenheimer (Lepidoptera: Noctuidae) includes the original combination and reference of each name, distribution and indications of references containing illustrations of valid species and subspecies. *Heliothis neckerensis* n. n. is proposed for *Helicoverpa pallida* Hardwick, secondary homonym of *Heliothis pallida* (Butler). Twelve new combinations are noted.

This cross-indexed alphabetical checklist of the species-group names of the genus *Heliothis* Ochsenheimer has been developed from the literature and does not reflect a personal opinion as to the placement, validity or status of the entities included except as noted. The list has been prepared primarily for use by workers concerned with studies of the economically important species of the genus, especially with biological control of such species.

Hardwick (1965a:10; 1970:30) has been followed in the inclusion in *Heliothis* of certain species formerly in *Timora* Walker, 1856 and *Canthylidia* Butler, 1886. Other species that have been included in those genera and other related genera remain to be studied to determine whether they are congeneric. Undoubtedly a supplementary list will need to be prepared at some future date.

Hardwick (1970:18) feels that if the corn earworm group (*Helicoverpa* Hardwick, 1965) is included in *Heliothis*, the species of *Schinia* Hübner, 1818 should also be transferred to *Heliothis*. That premise does not hold if the characters on which his classification was based are given a different weight or significance. Accordingly, *Helicoverpa* Hardwick is treated as a synonym of *Heliothis*, and the species of *Schinia* have not been included in this list.

A few species have been either deliberately excluded or tentatively included. *Noctua scutosa* Denis & Schiffermüller, 1775, a species commonly placed in *Heliothis*, but now standing in *Protoschinia* Hardwick, 1970 has not been included. Hardwick believes that it is an intermediate species between *Heliothis* and *Schinia*. Conversely, one included species, *Chloridea chilensis* Hampson, 1903 may not belong in the genus. It has been placed in the genus *Schinia* by Hardwick (1966:870), but I am not convinced his arguments are valid. *Poaphila*? *turbata* Walker, 1858 and its junior synonym, *Perigea albidentina* Walker, 1865 have usually been placed in *Heliothis*, but the former has been treated in recent years as an unrecognized or "lost" species. Mr. Alan Hayes of the British Museum (Natural History) has examined and has sent colored photographic slides of the types of those two names for my examination. He is of the opinion that these are older names for the species described by Grote, 1875 as *Heliothis lupatus.* I agree with that opinion and the names are so treated in this list. *Chloridea distincta* Schaus, *Aspila tergemina* Felder and Rogenhofer and *Chloridea molochitina* Berg with its synonym, *Thyreion olivofusa* Dognin, have usually been placed as junior synonyms of *Heliothis virescens* (F.) by most workers. I am convinced they are good species and have treated them as such in the checklist.

The generic name, *Heliothis*, is masculine in gender, but has usually been treated as feminine. In addition, names proposed in feminine genera have been transferred to *Heliothis* unchanged. All necessary changes to masculine endings have been made in this paper, and the incorrect feminine spellings are shown in parentheses for convenience of workers wishing to conduct bibliographic searches.

In the past some species of the corn earworm complex have been misidentified as *Heliothis armigera* Hübner or *Heliothis obsoleta* (F.). These numerous misidentifications have not been included in this list as they can be found in the extensive bibliography prepared by Hardwick (1965a:133–208).

The numbers in parentheses and brackets following each species listed refer to the numbered list of references. The numbers in parentheses indicate references where illustrations of adults may be found; those in brackets refer to illustrations of genitalia, male and/or female.

Genus **Heliothis** Ochsenheimer

Heliothis Ochsenheimer, 1816. Schmett. Eur. 4: 91.

Type-species: *Phalaena dipsacea* Linnaeus, 1767. Syst. Nat. (Edn. 12), 1:856 (= *Phalaena viriplaca* Hufnagel, 1766. Berlin. Mag. 3(4):406) by subsequent designation by Samouelle, 1819. Entomologist's useful Compendium. P. 252.

Chloridea Duncan [& Westwood], 1841. *In* Jardine, Naturalist's Library (Edn. 1). 33(Ent. 7):198.

Type-species: *Phalaena rhexiae* J. E. Smith, 1797. *In* Smith & Abbott, Nat. Hist. Rarer Lepid. Insects Georgia. P. 199 (= *Noctua virescens* Fabricius, [1777]. Genera Insect. P. 282) by monotypy.

Aspila Guenée, 1852. *In* Boisduval & Guenée, Hist. Nat. Insectes. Sp. Gén. Lépid. 6(Noct. 2):174.

Type-species: *Noctua virescens* Fabricius, [1777]. Genera Insect. P. 282 by subsequent designation by Hampson, 1903. Cat. Lepid. Phalaenae Br. Mus. 4:34.

Timora Walker, 1856. List of specimens of lepidopterous insects in the collection of the British Museum. Pt. 9, pp. 69, 132.

Type-species: *Nonagria senegalensis* Guenée, 1852. *In* Boisduval & Guenée, Hist. Nat. Insectes. Sp. Gén. Lépid. 5(Noct. 1):110 by monotypy.

Heliocheilus Grote, 1865. Proc. Entomol. Soc. Phila. 4:328.

Type-species: *Heliocheilus paradoxus* Grote, 1865. *Ibidem.* 4:329 by monotypy.

Rhodosea Grote, 1883. Can. Entomol. 15:4.

Type-species: *Rhodosea julia* Grote, 1883. *Ibidem.* 15:5 by monotypy.

Dysocnemis Grote, 1883. Trans. Amer. Entomol. Soc. 10:263.

Type-species: *Melicleptria belladonna* Hy. Edwards, 1881. Papilio. 1:20 by original designation.

Canthylidia Butler, 1886. Trans. R. Entomol. Soc. Lond. 1886, p. 406.

Type-species: *Canthylidia pallida* Butler, 1886. *Ibidem.* 1886, p. 406 (= *Leucania invaria* Walker, 1856. List of specimens of lepidoterous insects in the collection of the British Museum. Pt. 9, p. 111) by monotypy.

Helicoverpa Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 9.

Type-species: *Noctua armigera* Hübner, [1803–1808]. Samml. Eur. Schmett. 4: pl. 79, fig. 370 by original designation.

acesias Felder & Rogenhofer—Jr. syn. of **phloxiphagus**.
adauctus (adaucta) Butler—Jr. syn. of **viriplaca**.
afer (afra) (Hardwick)—Subsp. of **assulta**. Africa.
albidus (albida) Cockayne—Ab. of **maritimus warnecki**.
albidus (albida) Fuchs—Form of **viriplaca**.
albidentina (Walker)—Jr. syn. of **turbatus**.
albivenatus (albivenata) (Hampson). Somaliland (8, 11).
Chloridea albivenata Hampson, 1916. Proc. Zool. Soc. Lond. 1916, p. 103, pl. 1, fig. 3.
alphea (Cramer)—Jr. syn. of **peltiger**.
anartoides (Strand)—Jr. syn. of **belladona**.
angarensis (Draudt)—Subsp. of **viriplaca**. China.
aresca (Turner)—Jr. syn. of **rubrescens**.
armiger (armigera) **armiger** (Hübner). Eastern Hemisphere (3, 9, 12, 21, 22, 25, 26) [3, 12, 15, 25].
Noctua armigera Hübner [1803–1808]. Samml. Eur. Schmett. 4: pl. 79, fig. 370.

Noctua barbara Fabricius, 1794. Entomol. Syst. 3, 2:111. Hardwick (1965b, ref. 13) considered this a senior synonym, but applied to Interational Commission on Zoological Nomenclature for rejection as a *nomen oblitum.*

Heliothis pulverosa Walker, 1857. List of specimens of lepidopterous insects in the collection of the British Museum. Pt. 11, p. 688.

Heliothis uniformis Wallengren, 1860. Weiner Entomol. Monatschr. 4:171.

Heliothis obsoleta Auctorum *nec* (F.) (in part). Misidentifications.

Chloridea obsoleta ab. *rufa* Warren, 1911. *In* Seitz, Die Gross-Schmetterlinge der Erde. 3:246.

Heliothis armigera form *fusca* Cockerell, 1889. Entomologist. 22:4.

armiger commoni (Hardwick) **n. comb.** Canton Island.

Helicoverpa armigera commoni Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 101, figs. 116–117.

armiger confertus (conferta) Walker. Indonesia, Australia & Oceania.

Heliothis conferta Walker, 1857. List of specimens of lepidopterous insects in the collection of the British Museum. Pt. 11, p. 690.

assulta assulta Guenée. Asia, Africa, Australia & Oceania (3, 8, 9, 12, 22, 27) [3, 12].

Heliothis assulta Guenée, 1852. *In* Boisduval & Guenée, Hist. Nat. Insectes. Sp. Gén. Lépid. 6(Noct. 2):178.

Heliothis separata Walker, 1857. List of specimens of lepidopterous insects in the collection of the British Museum. Pt. 11, p. 691.

Heliothis succinea Moore, 1881. Proc. Zool. Soc. Lond. 1881, p. 362.

Heliothis temperata Walker, 1857. List of the specimens of lepidopterous insects in the collection of the British Museum. Pt. 11, p. 689.

assulta afer (afra) (Hardwick) **n. comb.** Africa.

Helicoverpa assulta afra Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 123, fig. 131.

atacamae (Hardwick) **n. comb.** Chile & Perú (12) [12].

Helicoverpa atacamae Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 81, figs. 106–107.

aurantiacus (aurantiaca) (Strand)—Ab. of **peltiger.**

barbarus (barbara) (F.)—Jr. syn. of **peltiger** vide Hampson, syn. of **armiger** vide Hardwick.

belladona (Hy. Edwards). Western USA (9, 16) [15].

Melicleptria belladona Hy. Edwards, 1881. Papilio. 1:20.

Dysocnemis anartoides Strand, 1914. Arch. Naturgesch. 80A, 2:161.

borealis (Hampson). Eastern Canada (9).

Dysocnemis borealis Hampson, 1903. Cat. Lepid. Phalaenae Br. Mus. 4:24, pl. 55, fig. 6.

bracteae (Hardwick) **n. comb.** Paraguay, Argentina & Perú (12) [12].

Helicoverpa bracteae Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 74, figs. 27–29, 102.

bulgaricus (bulgarica) (Draudt)—Subsp. of **maritimus**. SE Europe.

caesius (caesia) (Warren). Queensland (27).

Chloridea caesia Warren, 1926. *In* Seitz, Die Gross-Schmetterlinge der Erde. 11:308, pl. 27, row i.

canariensis (Warren)—Ab. of **viriplaca**.

centralasiae (Draudt)—Subsp. of **maritimus**. Asia.

charmione (Stoll)—Jr. syn. of **peltiger**.

chilensis (Hampson). Chile (4, 9, 14) [14]. In *Schinia* vide Hardwick, 1966.

Chloridea chilensis Hampson, 1903. Cat. Lepid. Phalaenae Br. Mus. 4:48, pl. 55, fig. 24.

clarissimus (clarissima) (Turati)—Form of **peltiger**.

commoni (Hardwick)—Subsp. of **armiger**. Canton Island.

condolens Schawerda—Ab. of **peltiger**.

confertus (conferta) Walker—Subsp. of **armiger**. Indonesia, Australia & Oceania.

confusus (confusa) (Hardwick) **n. comb.** Hawaii (12) [12].

Helicoverpa confusa Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 116, figs. 123–124.

conifer (conifera) (Hampson). Transvaal.

Chloridea conifera Hampson, 1913. Ann. Mag. Nat. Hist. (8). 12:580.

cystiphorus (cystiphora) (Wallengren). Panamá & Galapagos Islands (4).

Anthoecia cystiphora Wallengren, 1860. Wiener Entomol. Monatschr. 4:172 ♂.

Anthoecia inflata Wallengren, 1860. *Ibidem.* 4:172 ♂.

Anthoecia onca Wallengren, 1860. *Ibidem.* 4:172 ♀.

dejeani Oberthür. China (18, 26).

Heliothis dejeani Oberthür, 1893. Et. Entomol. 18:44, pl. 3, fig 40.

desertus (deserta) (Sohn-Rethel)—Var. of **nubiger**.

designatus (designata) (Brandt). Iran (2).

Heliocheilus designata Brandt, 1947. Mitt. Münchn. Entomol. Ges. 31: 853.

dipsaceus (dipsacea) (L.)—Jr. syn. of **viriplaca**.

distinctus (distincta) (Schaus). Perú (4).

Chloridea distincta Schaus, 1898. J. N.Y. Entomol. Soc. 6:117.

errans Walker—Jr. syn. of **scutuliger**.

ferrugineus (ferruginea) Spuler—Ab. of **maritimus**.

fervens Butler. Japan & China (9, 22).

Heliothis fervens Butler, 1881. Trans. R. Entomol. Soc. Lond. 1881, p. 186.

Heliothis foveolatus Staudinger, 1888. Stett. Entomol. Zeit. p. 263.

Heliocheilus fervens ab. *macularis* Warren, 1911. *In* Seitz, Die Gross-Schmetterlinge der Erde. 3:245.

fimbria (Williams)—Jr. syn. of **proruptus**.

flavescens (Janse). Natal.

Chloridea flavescens Janse, 1917. Ann. Durban Mus. 1:472.

flaviger (flavigera) **flaviger** (Hampson). Africa (25) [25].

Chloridea flavigera Hampson, 1907. Ann. Mag. Nat. Hist. (7). 19:242.

flaviger insularis Viette. Madagascar.

Heliothis flavigera insularis Viette, 1967. Faune de Madagascar. 20(2):772, figs. 603, 605, 611.

fletcheri (Hardwick) **n. comb.** Western Africa (12) [12].

Helicoverpa fletcheri Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 129, figs. 132–133.

florentinus (florentina) (Esper)—Jr. syn. of **peltiger**.

foveolatus Staudinger—Jr. syn. of **fervens**.

fumatus (fumata) (Lucas)—Jr. syn. of **invarius**.

fuscimacula (Janse). Natal.

Chloridea fuscimacula Janse, 1917. Ann. Durban Mus. 1:469.

fuscus (fusca) Cockerell—Form of **armiger**.

gelotopoeus (gelotopoeon) (Dyar). Southern South America (4, 12) [12, 23].

Thyreion gelotopoeon Dyar, 1921. Insec. Inscit. Menst. 9:60.

?*Thyreion giacomelli* Koehler, 1939. Physis. 17:451.

?*Thyreion lizeri* Koehler, 1939. Physis. 17:450.

giacomelli (Koehler)—Jr. syn. of **gelotopoeus**.

grandis (Druce)—Jr. syn. of **julia**.

guidellii Costantini. Italy.

Heliothis guidellii Costantini, 1922. Neue Breiträge Syst. Insektenk. 2:99.

hawaiiensis Quaintance & Brues. Hawaii (12, 28, 29) [12, 28, 29].

Heliothis obsoleta var. *hawaiiensis* Quaintance & Brues, 1905. USDA, Bur. Entomol. Bull. 50:12.

Chloridea obsoleta signata Warren, 1926. *In* Seitz, Die Gross-Schmetterlinge der Erde. 11:308.

Chloridea armigera ab. *hawaiiensis* (Strand), 1916. Arch. Naturgesch. 81(A), 12:143. Preoccupied.

hawaiiensis (Strand)—Jr. syn. of **hawaiiensis** Quaintance & Brues. Preoccupied.

helenae (Hardwick) **n. comb.** St. Helena Island (12) [12].

Helicoverpa helenae Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 106, figs. 118–119.

hungaricus (hungarica) (Kovács)—Jr. syn. of **maritimus bulgaricus**.

hyalostictus (hyalosticta) Hampson. India & Burma (9, 27).

Heliothis hyalosticta Hampson, 1896. Moths of India. 4:507.

hyperchroa Turner—Jr. syn. of **rubrescens**.
hyperfuscus (hyperfusca) (Strand)—Ab. of **paradoxus**.
inflatus (inflata) (Wallengren)—Jr. syn. of **cystiphorus**.
insularis Viette—Subsp. of **flaviger**. Madagascar.
insulatus (insulata) (Navás)—Var. of **peltiger**.
intensivus (intensiva) (Warren)—Ab. of **ononis**.
interjacens Grote—Jr. syn. of **phloxiphagus**.
invarius (invaria) **invarius** (Walker). Queensland (9) [15].
  Leucania invaria Walker, 1856. List of the specimens of lepidopterous insects in the collection of the British Museum. Pt. 9, p. 111.
  Canthylidia pallida Butler, 1886. Trans. R. Entomol. Soc. Lond. 1886, p. 406, pl. 9, fig. 9.
  Leucania fumata Lucas, 1889. Proc. Linn. Soc. N. S. Wales. (2). 4:1098.
invarius pallescens (Warren). West Australia.
  Canthylidia invaria pallescens Warren, 1926. *In* Seitz, Die Gross-Schmetterlinge der Erde. 11:312, pl. 28, row a.
jefferyi (Janse). Transvaal.
  Chloridea jefferyi Janse, 1917. Ann. Durban Mus. 1:470.
julia (Grote). Western USA & México (9, 16) [15].
  Rhodosea julia Grote, 1883. Can. Entomol. 15:5.
  Adisura grandis Druce, 1890. Proc. Zool. Soc. Lond. 1890, p. 516.
lizeri (Koehler)—Jr. syn. of **gelotopoeus**.
lugubris Klemensiewicz—Ab. of **ononis**.
lupatus (lupata) Grote—Jr. syn. of **turbatus**.
luteitinctus (luteitincta) Grote—Form of **phloxiphagus**.
macularis (Warren)—Ab. of **fervens**.
maritimus (maritima) **maritimus** Graslin. Palearctic (7) [7].
  Heliothis maritima Graslin, 1855. Ann. Soc. Entomol. Fr. (3). 3:68, pl. 7.
  Heliothis spergulariae Lederer, 1857. Noct. Eur. p. 230.
  Heliothis maritima ab. *ferruginea* Spuler, 1908. Schmett. Eur. 1:281.
  Heliothis maritima form *obscura* Lempke, 1941. Tijdschr. Entomol. 84:337.
maritimus bulgaricus (Draudt). Southeast Europe.
  Chloridea maritima bulgarica Draudt, 1938. Entomol. Rdsch. 55:307 and 1938. Rev. Franç. Lepidopt. 9:90.
  Chloridea maritima hungarica Kovács, 1950. Folia Entomol. Hung. (N. S.). 3:68.
maritimus centralasiae (Draudt). Asia.
  Chloridea maritima centralasiae Draudt, 1938. Entomol. Rdsch. 55:308 and 1938. Rev. Franç. Lepidopt. 9:90.
maritimus warneckei (Boursin). Europe.
  Chloridea maritima warneckei Boursin, 1963. Linn. Belg. 2:125 and 1964. Bull. Mens. Soc. Linn. Lyon. 33:240.

Heliothis maritima septentrionalis Hoffmeyer, 1938. Flora og Fauna. 44:6. Preoccupied.

Heliothis maritima septentrionalis ab. *albida* Cockayne, 1951. Entomol. Rec. 63:160.

marmada (Swinhoe)—Jr. syn. of **punctiger**.

mekranus (mekrana) (Brandt). Iran (2).

Heliocheilus mekrana Brandt, 1947. Mitt. Münchn. Entomol. Ges. 31:852.

metachriseus (metachrisea) (Hampson). Madagascar (25) [25].

Chloridea metachrisea Hampson, 1903. Cat. Lepid. Phalaenae Br. Mus. 4: 42, pl. 55, fig. 18.

minutus (minuta) (Hardwick) **n. comb.** Lisianski Island (12) [12].

Helicoverpa minuta Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 118, figs. 125–126.

molochitinus (molochitina) (Berg). Southern South America.

Chloridea molochitina Berg, 1882. Ann. Soc. Argentina. 14:282.

Thyreion olivofusa Dognin, 1907. Ann. Soc. Entomol. Belg. 51:230.

nana (Hampson). Tibet (10).

Chloridea nana Hampson, 1906. Proc. Zool. Soc. Lond. 1906, p. 487.

neckerensis n. n. for *Helicoverpa pallida* Hardwick. Necker Island (12) [12].

Helicoverpa pallida Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 89, fig. 111. Preoccupied by *Heliothis pallida* (Butler), 1886.

neckerensis nihoaensis (Hardwick) **n. comb.** Nihoa Island (14).

Helicoverpa pallida nihoaensis Hardwick, 1966. Can. Entomol. 98(8): 867, fig. 2.

nihoaensis (Hardwick)—Subsp. of **neckerensis**. Nihoa Island.

nubiger (nubigera) Herrich-Schäffer. Palearctic (7, 26).

Heliothis nubigera Herrich-Schäffer, 1851. Syst. Bearbeit. Schmett. Eur. 2:366.

Heliothis perigeoides Moore, 1881. Proc. Zool. Soc. Lond. 1881, p. 361.

Chloridea nubigera var. *deserta* Sohn-Rethel, 1929. Iris. 43:14.

obscurus (obscura) Lempke—Form of **maritimus**.

obscurus (obscura) (Lempke)—Form of **peltiger**.

obsoletus (obsoleta) (F.)—Syn. of **zea**.

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oenotryx (Boursin)—Subsp. of **viriplaca**. Spain.

olivarius (olivaria) Graeser. Amurland.

Heliothis olivaria Graeser, 1888. Berlinger Entomol. Ztschr. 32:365.

olivofusus (olivofusa) (Dognin)—Jr. syn. of **molochitinus**.

omicronatus (omicronata) Richardson—Ab. of **peltiger**.

onca (Wallengren)—Jr. syn. of **cystiphorus**.

ononidis Guenée—Jr. syn. of **ononis**.

ononis (Denis & Schiffermüller). Holarctic (4, 7, 18, 21, 26).

Noctua ononis Denis & Schiffermüller, 1775. Ankündung eines systematischen Werkes von den Schmetterlingen der Weinergregend . . . Wien. P. 89.
Chloridea ononis ab. *intensiva* Warren, 1911. *In* Seitz, Die Gross-Schmetterlinge der Erde. 3:245, pl. 50, row k.
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Heliothis ononis ab. *lugubris* Klemensiewicz, 1912. Spraw. Kom. Fizyogr. Krakow. 46:14.
Heliothis ononidis Guenée, 1852. *In* Boisduval & Guenée, Hist. Nat. Insectes. Sp. Gén. Lépid. 6(Noct. 2):182. An invalid emendation of *ononis.*

oregonicus (oregonica) (Hy. Edwards). Western USA (1, 9, 16).
Melicleptria oregonica Hy. Edwards, 1875. Proc. Calif. Acad. Sci. 6: 135.

pacificus (pacifica) (Hardwick) **n. comb.** Jarvis Island (12) [12].
Helicoverpa pacifica Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 119, fig. 128.

pallescens (Warren)—Subsp. of **invarius**. West Australia.
pallidus (pallida) (Butler)—Jr. syn. of **invarius**.
pallidus (pallida) (Hardwick)—Syn. of **neckerensis**. Preoccupied.
pallidus (pallida) (Lempke)—Form of **viriplaca**.
pallidus (pallida) Cockerell—Form of **peltiger**.

paradoxus (paradoxa) (Grote). USA (4, 9, 16, 17) [15].
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pauliana Hardwick—Jr. syn. of **pauliani**.

pauliani Viette. Amsterdam Island & Indian Ocean (24).
Heliothis pauliani Viette, 1959. Bull. Soc. Entomol. Fr. 64(2):27.
Heliothis pauliana [sic], Hardwick, 1966. Can. Entomol. 98(8):869. *Lapsus pro pauliani.*

peltiger (peltigera) (Denis & Schiffermüller). Palearctic (7, 21, 26).
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Chloridea peltigera form *clarissima* Turati, 1924. Atti Soc. Ital. Sci. Nat. 63:101.
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perigeoides Moore—Jr. syn. of **nubiger.**

phloxiphagus (phloxiphaga) Grote & Robinson. North America (4, 9).
Heliothis phloxiphagus Grote & Robinson, 1867. Trans. Amer. Entomol. Soc. 1:187.
Heliothis acesias Felder & Rogenhofer, 1872. Reise Novara . . . Atlas, Inhalts-Verzeichniss Heterocera. P. 11, pl. 108, fig. 42.
Heliothis luteitinctus Grote, 1875. Proc. Acad. Nat. Sci. Phila. P. 426.
Heliothis interjacens Grote, 1880. Bull. Brooklyn Entomol. Soc. 3:30.
Heliothis phlogophagus Grote, 1882. List N. Amer. Moths. P. 36.

phlogophagus Grote—Jr. syn. of **phloxiphagus.**

posttriphaenus (posttriphaena) (W. Rothschild). Madagascar (25) [25].
Chloridea posttriphaena W. Rothschild, 1924. Ann. Mag. Nat. Hist. (9). 14:310.

prasinus (prasina) (Walker)—Jr. syn. of **virescens.**

proruptus (prorupta) Grote. Western USA (9).
Heliothis proruptus Grote, 1873. Trans. Amer. Entomol. Soc. 4:294.
Melicleptria fimbria Williams, 1905. Entomol. News. 16:237.
Melicleptria venusta Hy. Edwards, 1875. Proc. Calif. Acad. Sci. 6:133.

pulverosus (pulverosa) Walker—Jr. syn. of **armiger.**

punctiger (punctigera) Wallengren. Australia (3, 12) [3, 12].
Heliothis punctigera Wallengren, 1860. Wiener Entomol. Montaschr. 4: 171.
Chloridea marmada Swinhoe, 1918. Ann. Mag. Nat. Hist. (9). 2:65.

pyraloides (Walker)—Jr. syn. of **virescens.**

rhexiae (J. E. Smith)—Jr. syn. of **virescens.**

richinii (Berio). Eritrea.
Chloridea richinii Berio, 1939. Boll. Soc. Entomol. Ital. 71:164.

rosario (Barnes)—Jr. syn. of **toralis.**

rubrescens (Walker). Australia (3, 27) [3].

Thalpophila rubrescens Walker, 1858. List of the specimens of lepidopterous insects in the collection of the British Museum. Pt. 15, p. 1681.

Chloridea aresca Turner, 1911. Ann. Queensland Mus. 10:60.

Heliothis hyperchroa Turner, 1920. Trans. R. Soc. S. Aust. 44:131.

rufus (rufa) Warren. New Guinea (27).

Chloridea rufa Warren, 1926. *In* Seitz, Die Gross-Schmetterlinge der Erde. 11:308, pl. 27, row i.

rufus (rufa) (Warren)—Ab. of **armiger**.

salmantinus (salmantina) (Fernandez)—Form of **viriplaca**.

scutuliger (scutuligera) Guenée. Africa (8, 9).

Heliothis scutuligera Guenée, 1852. *In* Boisduval & Guenée, Hist. Nat. Insectes, Sp. Gén. Lépid. 6(Noct. 2):180.

Heliothis errans Walker, 1865. List of the specimens of lepidopterous insects in the collection of the British Museum. Pt. 33, p. 769.

senegalensis (Guenée). Senegal.

Nonagria senegalensis Guenée, 1852. *In* Boisduval & Guenée, Hist. Nat. Insectes, Sp. Gén. Lépid. 5(Noct. 1):110.

separatus (separata) Walker—Jr. syn. of **assulta**.

septentrionalis (Hy. Edwards)—Jr. syn. of **ononis**.

septentrionalis Hoffmeyer—Syn. of **maritimus warneckei**. Preoccupied.

signatus (signata) (Warren)—Jr. syn. of **hawaiiensis**.

spectandus (spectanda) Strecker—Jr. syn. of **virescens**.

spergulariae Lederer—Jr. syn. of **maritimus**.

stramineus (straminea) (Donovon)—Jr. syn. of **peltiger**.

stombleri Okumura & Bauer. Western USA (19) [19].

Heliothis stombleri Okumura & Bauer, 1969. Bur. Entomol., Calif. Dept. Agric. Occ. Pap. No. 18, p. 2, figs. 1–12.

sturmhoefeli Draudt. Brazil (4).

Heliothis sturmhoefeli Draudt, 1927. *In* Seitz, Die Gross-Schmetterlinge der Erde. 7:335, pl. 47, row m.

subflexus (subflexa) (Guenée). Western Hemisphere (17) [6].

Aspila subflexa Guenée, 1852. *In* Boisduval & Guenée, Hist. Nat. Insectes, Sp. Gén. Lépid. 6(Noct. 2):175.

succineus (succinea) Moore—Jr. syn. of **assulta**.

temperatus (temperata) Walker—Jr. syn. of **assulta**.

tergeminus (tergemina) (Felder & Rogenhofer). South America (5).

Aspila tergemina Felder & Rogenhofer, 1872. Reise Novara . . . Atlas, Inhalts-Verzeichniss Heterocera. P. 3, fig. 55.

tertius (tertia) Roepke. Java (20).

Heliothis tertia Roepke, 1941[1945]. Zool. Meded. 23:14, pl. 2, fig. 7.

tibetensis (Hardwick) **n. comb.** Tibet (12) [12].

Helicoverpa tibetensis Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 131, fig. 136.

titicacae (Hardwick) **n. comb.** Perú (12) [12].

Helicoverpa titicacae Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 75, figs. 23–26, 101.

toddi (Hardwick). Africa & Madagascar (12) [12, 25].

Helicoverpa toddi Hardwick, 1965. Mem. Entomol. Soc. Can. No. 40, p. 128, figs. 133–135.

toralis (Grote). Southwestern USA.

Botis toralis Grote, 1881. Papilio. 1:178.

Prothymia rosario Barnes, 1904. Can. Entomol. 36:264.

Pseudacontia unicolor Walters, 1928. Proc. Entomol. Soc. Wash. 30: 138.

translucens (Felder & Rogenhofer). Himalayas (27).

Heliocheilus translucens Felder & Rogenhofer, 1872. Reise Novara . . . Atlas, Inhalts-Verzeichniss Heterocera. P. 11, pl. 108, fig. 49.

tristis Stauder—Form of **viriplaca**.

turbatus (turbata) (Walker). Florida to Maryland (4).

Poaphila? tubata Walker, 1858. List of specimens of lepidopterous insects in the collection of the British Museum. Pt. 15, p. 1834.

Perigea albidentina Walker, 1865. *Ibidem*. Pt. 32, p. 680.

Heliothis lupatus Grote, 1875. Can. Entomol. 7:224.

umbrosus Grote—Jr. syn. of **zea**.

unicolor (Walters)—Jr. syn. of **toralis**.

uniformis Wallengren—Jr. syn. of **armiger**.

venustus (venusta) (Hy. Edwards)—Jr. syn. of **proruptus**.

virescens (F.). Western Hemisphere & Hawaii (4, 16, 17, 28) [6, 15, 28].

Noctua virescens Fabricius, 1777. Genera Insect. P. 282.

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Xanthia pyraloides Walker, 1856. *Ibidem*. Pt. 10, p. 466.

Xanthia viridescens Walker, 1856. *Ibidem*. Pt. 10, p. 465.

Heliothis spectanda Strecker, 1875. Lepid. Rhop. & Het. P. 122.

viridescens (Walker)—Jr. syn. of **virescens**.

viriplaca viriplaca (Hufnagel). Palearctic (5, 22, 26) [5, 12, 15].

Phalaena viriplaca Hufnagel, 1766. Berlin. Mag. 3(4):406.

Noctua dipsacea Linnaeus, 1767. Syst. Nat. (Edn. 12). 1:856.

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Chloridea dipsacea ab. *canariensis* Warren, 1911. *In* Seitz, Die Gross-Schmetterlinge der Erde. 3:245, pl. 50, row i.

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Chloridea viriplaca form *pallida* Lempke, 1966. Tijdschr. Entomol. 109 (9):234.

viriplaca angarensis (Draudt). China.

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warneckei (Boursin)—Subsp. of **maritimus**.

xanthiatus (xanthiata) Walker. Africa (8, 9).

Heliothis xanthiata Walker, 1865. List of specimens of lepidopterous insects in the collection of the British Museum. Pt. 33, p. 770.

zea (Boddie). Western Hemisphere & Hawaii (4, 12, 15, 17, 28, 29) [3, 12, 23, 28, 29].

Phalaena zea Boddie, 1850. South. Cultivator. 8:132.

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Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o NHB-127, U.S. National Museum, Washington, D.C. 20560.

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THE BRACONID PARASITES (HYMENOPTERA) OF *HELIOTHIS* SPECIES (LEPIDOPTERA: NOCTUIDAE)

Paul M. Marsh

Abstract.—A key and a brief diagnosis of each species are given for the braconid parasites of *Heliothis* species in North America. The braconid parasites which have been introduced but which are not established are included. A table listing Old World records of parasites is also given. *Microplitis indicus*, n. sp., is described from India; *Chelonus texanus* is placed in synonymy with *C. insularis*.

The purpose of this paper is to present information on the identity of the braconid parasites of *Heliothis* species as an aid to biological control workers in North America. An illustrated key to the North American species is presented and includes species that have been introduced but not established; a brief diagnosis and discussion are given for each species. Also presented is a list of Old World species that have been recorded from *Heliothis* species.

Most of the introduced parasitic braconids have come from India, but from the list of parasites in the Old World, there are plainly many other possible parasites in southern Europe, Asia and Africa. No parasites have been introduced from South America though several North American parasites also occur in the Neotropical Region. I therefore feel this largely unexplored area offers the best opportunity for further searches for *Heliothis* parasites.

To avoid repetition, I have listed the names and authors of the lepidopteran hosts mentioned in this paper. The spellings for specific names in *Heliothis* are based on a study by Todd (1978).

Chilo plejadellus Zinck.
Chilo zonellus (Swin.)
Colias eurytheme Bdvl.
Corcyra cephalonica Stain.
Diatraea saccharalis (F.)
Elaphria nucicolora (Guen.)
Ephestia elutella (Hbn.)
Faronta diffusa (Wlkr.)
Feltia subterranea (F.)
Heliothis armiger (Hbn.)
Heliothis assulta Guen.
Heliothis dipsaceus (L.)
Heliothis obsoletus (F.)
Heliothis ononis (D. & S.)
Heliothis peltiger (D. & S.)
Heliothis subflexus (Guen.)
Heliothis virescens (F.)
Heliothis viriplaca (Huf.)
Heliothis zea (Boddie)
Leucania latiuscula (H.-S.)
Lineodes integer (Zell.)
Lineodes interruptus Zell.
Loxostege sticticalis (L.)
Ostrinia nubilalis (Hbn.)
Papaipema nebris (Guen.)
Pectinophora gossypiella (Saund.)
Peridroma saucia (Hbn.)
Phthorimaea operculella (Zell.)
Pilemia periusalis (Wlkr.)
Platynota stultana (Wlsm.)

Pseudaletia unipuncta (Haw.)
Semiothisa punctolineata (Pack.)
Spodoptera eridania (Cram.)
Spodoptera exigua (Hbn.)
Spodoptera frugiperda (Sm.)
Spodoptera ornithogalli (Guen.)
Spodoptera praefica (Grote)
Sylepta derogata (F.)
Symmetrischema heliopum (Low)
Trichoplusia ni (Hbn.)

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New World Braconidae Parasitic on *Heliothis* Species

Fifteen species of Braconidae have been recorded as parasites of *Heliothis* in North America. Of the 11 native species, only three—*Cardiochiles nigriceps* Viereck, *Microplitis croceipes* (Cresson), and *Chelonus insularis* Cresson (= *texanus*)—are important in the control of *Heliothis*, and they have been studied extensively. The other native species are only occasional parasites of *Heliothis*, and some of the records need to be confirmed. However, they should perhaps be examined further and are, therefore included in the key. The four introduced species have not become established. They have been included in the key in the event that further studies are made and that they do become established. One of the introduced species is described as new. Brief mention is made for two foreign species which were not introduced against *Heliothis* but for which there is data to indicate possible association with *Heliothis*.

Key to the North American Braconid Parasites of *Heliothis* Species (Including Those Introduced but not Established)

1\. Circular opening present between clypeus and mandibles, labrum concave (as in Fig. 1) 2
– Without a circular opening between clypeus and mandibles, labrum not concave (as in Fig. 2) 4
2\. Occipital carina present *Rogas perplexus* Gahan
– Occipital carina absent 3
3\. Thorax and abdomen finely granular and dull; antenna more than 20-segmented, the flagellomeres longer than wide *Bracon platynotae* (Cushman)
– Thorax smooth and shining; abdomen with some reticulation but shining; antenna less than 20-segmented, the flagellomeres about as wide as long *Bracon brevicornis* Wesmael
4\. Abdominal terga fused into a carapace 5
– Abdominal terga not fused, with several visible segments 7

5\. Antenna of female 16-segmented; carapace of male with transverse opening at apex (Fig. 4) *Chelonus* (*Microchelonus*) *heliope* Gupta

– Antenna of female more than 20-segmented; carapace of male without such an opening at apex 6

6\. Hind femur black; parastigma yellow, apical ½ of fore wing strongly infuscated (Fig. 11) *Chelonus* (*Chelonus*) *narayani* Subba Rao

– Hind femur orange at least on apical ½; parastigma black, fore wing uniformly lightly infuscated (Fig. 13) *Chelonus* (*Chelonus*) *insularis* Cresson

7\. Abdomen petiolate 8

– Abdomen sessile 9

8\. Ventral margins of petiole meeting at base and touching for nearly ½ length of petiole (Fig. 19) *Meteorus laphygmae* Viereck

– Ventral margins of petiole meeting considerably beyond base and touching for only short distance (Fig. 20) *Meteorus autographae* Muesebeck

9\. Third segment of radius in fore wing distinct and strongly recurved; 2nd segment of radius longer than 1st; fore wing with 3 cubital cells, 2nd longer than wide (Fig. 12) *Cardiochiles nigriceps* Viereck

– Third segment of radius absent or weakly sclerotized and straight; 2nd segment not longer than 1st if present; fore wing with 2 or 3 cubital cells, if with 3, then 2nd a small areolet and not longer than wide 10

10\. Second cubital cell of fore wing a small areolet (as in Fig. 16) 11

– Second cubital cell absent (as in Fig. 17) 13

11\. Vertex, temples, and mesonotum smooth and shining; hind femur short and stout, not more than 3× as long as greatest width *Microplitis croceipes* (Cresson)

– Vertex, temples, and mesonotum finely punctate and dull; hind femur slender, more than 3× as long as wide 12

12\. Tegula and abdominal terga 1–4 yellow in female, tegula of male yellow *Microplitis indica*, new species

– Tegula and abdominal terga of female and male brown or black *Microplitis melianae* Viereck

13\. Ovipositor long, about as long as abdomen; areola present on propodeum (Fig. 3); stigma clear medially; radius longer than intercubitus (Fig. 18) *Apanteles angaleti* Muesebeck

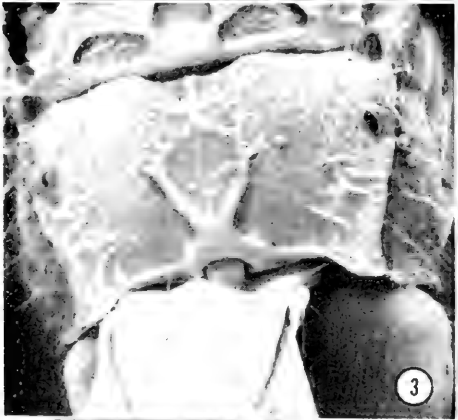
– Ovipositor short, shorter than 1st abdominal tergum; propodeum without areola; stigma brown; radius not longer than intercubitus 14

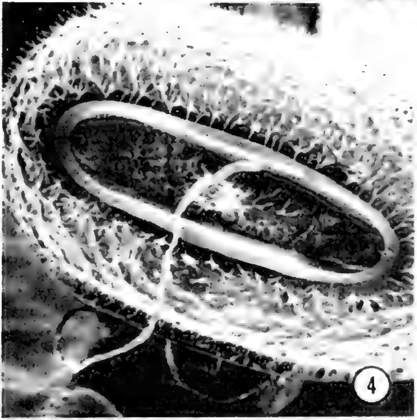
14\. First abdominal tergum wider at apex than at base, coarsely rugose (Fig. 5) *Apanteles marginiventris* (Cresson)

– First abdominal tergum narrower at apex than at base, smooth and polished (Fig. 6) *Apanteles militaris* (Walsh)


1


2


3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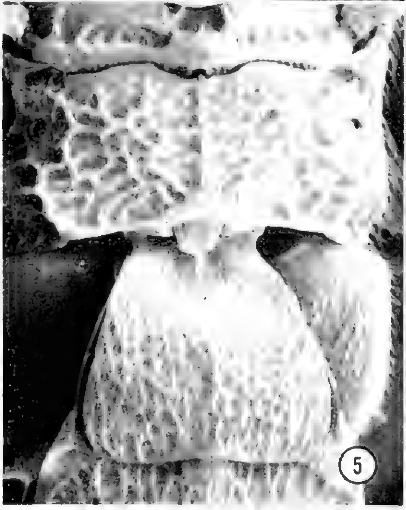
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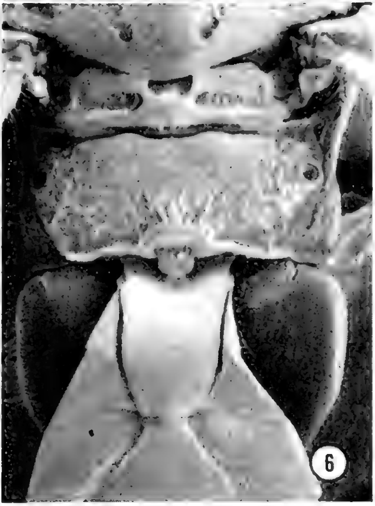
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Genus *Apanteles* Foerster

The only key for North American species is Muesebeck (1920). Wilkinson (1928) provides a key to the Indo-Australian species; Nixon (1972, 1973, 1974, 1976), northwestern European species; Telenga (1955), Russian species; Wilkinson (1932a), Ethiopian species.

Apanteles angaleti Muesebeck

Apanteles angaleti Muesebeck, 1954:61.

Diagnosis.—Length of body, 2.5–3.0 mm, ovipositor about 1 mm. Color: Body black, apex of fore femur, fore tibia and tarsus, basal ½ of mid tibia, mid tarsus, and basal ⅓ of hind tibia yellow, wings and veins hyaline, stigma hyaline with brown border, metacarpus brown, legs of male with more extensive dark coloration. Body: Head shallowly punctate and shining; mesonotum shallowly punctate, the punctures confluent along lines where notauli would be if present; scutellum flat, smooth and shining; propodeum rugose with a short median basal carina and areola strongly margined on apical end (Fig. 3); 1st abdominal tergum narrower at apex than at base and strongly punctate on apical ½, rest of terga smooth; ovipositor about as long as hind tarsus, hypopygium extending beyond apex of abdomen. Wing: Fore wing venation as in Fig. 18, radius perpendicular to anterior margin of wing and longer than intercubitus.

In Muesebeck's (1920) key to North American *Apanteles*, *angaleti* will run to *epinotae* but is distinguished by the first abdominal tergum being narrowed at the apex and the more distinctly punctate mesonotum. In Wilkinson's (1928) key to the Indo-Australian species, *angaleti* is similar to *araeceri* from Java, Malaya and India but is distinguished by the less densely sculptured mesonotum, slightly shorter ovipositor, and narrower first abdominal tergum.

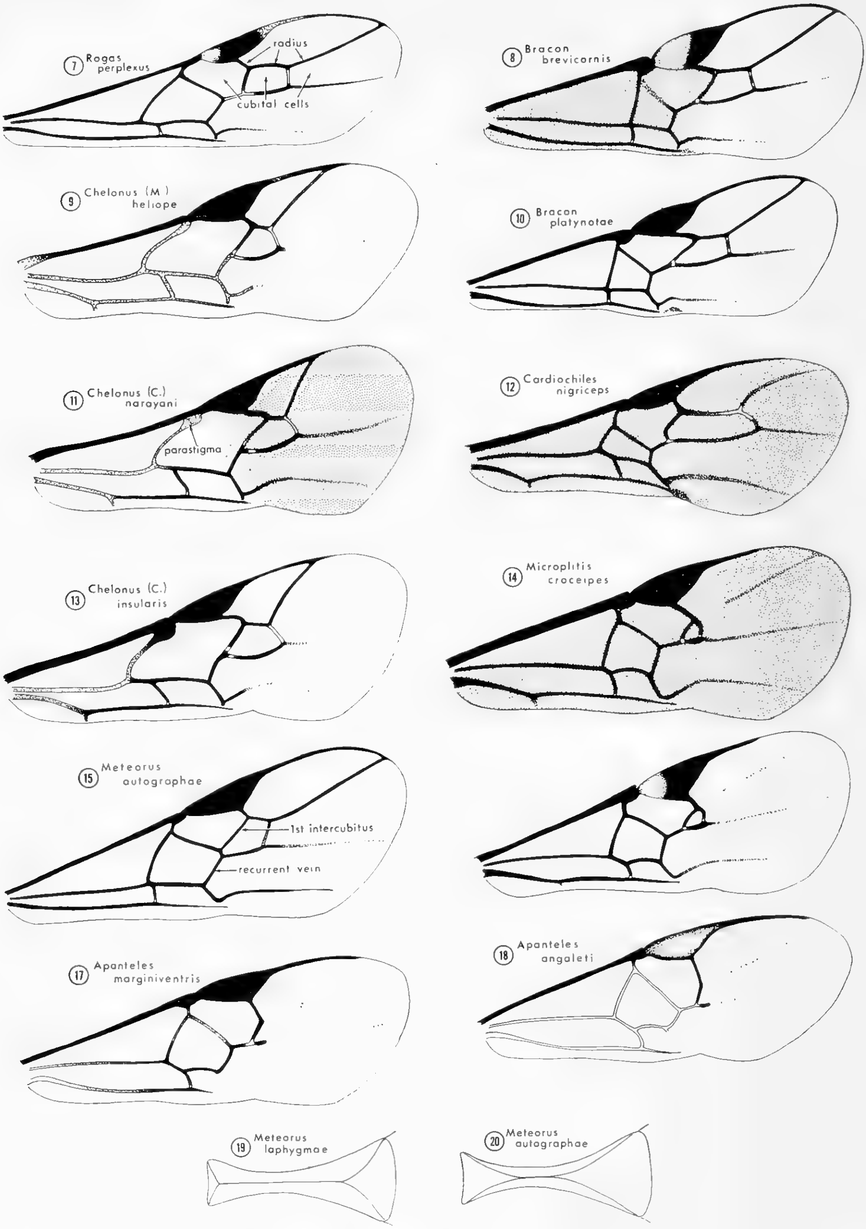
Distribution.—India, Sumatra. Introduced into Arizona, Florida, Mississippi, New Jersey, North Carolina, South Carolina, Tennessee, and Texas but not established.

Hosts.—Pectinophora gossypiella, Corcyra cephalonica, Sylepta derogata. Also released against *Heliothis virescens* and *H. zea* but not established.

Additional references (mostly biology on *Pectinophora gossypiella*).—Narayanan, Subba Rao and Gangrade (1956), Narayanan, Subba Rao and

←

Fig. 1. *Bracon platynotae*, face. Fig. 2. *Chelonus insularis*, face. Fig. 3. *Apanteles angaleti*, propodeum. Fig. 4. *Chelonus heliope*, apex of abdominal carapace. Fig. 5. *Apanteles marginiventris*, propodeum and first abdominal tergum. Fig. 6. *Apanteles militaris*, propodeum and first abdominal tergum.



Figs. 7–18. Wings of *Heliothis* parasites (stippling indicates shading only, wing hairs not indicated). Figs. 19–20. Ventral view of petiole in *Meteorus* spp.

Kaur (1959), Subba Rao and Gopinath (1961), Narayanan, Subba Rao and Thontadaraya (1962).

Comments.—This species was introduced into the United States as a possible biological control agent against both *Heliothis* spp. and *Pectinophora gossypiella*, but it did not become established on either pest. Nevertheless it appears to prefer the pink bollworm. More laboratory tests should be made to establish its use against *Heliothis*.

Apanteles marginiventris (Cresson)

Microgaster marginiventris Cresson, 1865:67.
Apanteles grenadensis Ashmead, 1900:278.
Apanteles laphygmae Ashmead, 1901:36. Nomen nudum.
Apanteles (*Protapanteles*) *harnedi* Viereck, 1912b:580.

Diagnosis.—Length of body, 2.0–2.5 mm. Color: Head and thorax black, antennal flagellum dark brown, scape yellow basally, tegula yellow, abdomen varying from entirely black to entirely orange, legs yellow, hind coxa often black, wings hyaline, veins brown. Body: Head punctate, dull; mesonotum punctate, dull, punctures confluent along lines of notauli; scutellum punctate; propodeum rugose with distinct median longitudinal carina (Fig. 5); abdominal terga 1–3 strongly rugose, occasionally weakly so on 3rd tergum, 1st tergum broader at apex than at base (Fig. 5); hind coxa punctate; inner spur of hind tibia longer than outer one; ovipositor about as long as last segment of hind tarsus. Wing: Fore wing venation as in Fig. 17.

This species is recognizable by the sculpturing on the abdomen and hind coxa, color, and length of the hind tibial spurs.

Distribution.—Eastern United States west to Wisconsin and Texas; Arizona, California. Mexico, West Indies, northern South America, Hawaii.

Host.—*Heliothis virescens* and *H. zea* plus numerous other Noctuidae, most often *Spodoptera frugiperda*.

Additional references (mostly concerning biology on *Spodoptera frugiperda*).—Luginbill (1928), Vickery (1929), Boling and Pitre (1970).

Comments.—This species is most often found as a parasite of the fall armyworm. It is frequently reared from *Heliothis* spp., but its significance in control is not well established.

Apanteles militaris (Walsh)

Microgaster militaris Walsh, 1861:369.

Diagnosis.—Length of body, 1.75–2.50 mm. Color: Body black, antenna brown, tegula yellow, abdomen light brown ventrally at base and occasionally laterally on terga 1 and 2, legs yellow, wings hyaline, veins brown. Body: Head and mesonotum shiny with scattered shallow punctures; scutellum smooth and shiny with scattered hair pits; propodeum (Fig. 6) finely rugose without median carina; abdomen smooth and polished, 1st tergum (Fig. 6) long and narrow, apex narrower than base; ovipositor barely exerted. Wing: Radius of fore wing perpendicular to anterior margin of wing and slightly shorter than intercubitus.

This species is easily distinguished by the narrow first abdominal tergum, smooth abdominal terga, and yellow legs.

Distribution.—North America, Puerto Rico, Argentina.

Hosts.—*Pseudaletia unipuncta*, *Heliothis zea*, and numerous other Noctuidae.

Additional references (concerning biology on *Pseudaletia unipuncta*).—Guppy (1967), Calkins and Sutter (1976).

Comments.—This species is a common parasite of the armyworm, and there are only a few records from *Heliothis zea*. It is therefore not considered important in the control of *Heliothis*.

Genus *Bracon* Fabricius

Muesebeck's (1925) key to species is the only one available for North America.

Bracon brevicornis Wesmael

Bracon brevicornis Wesmael, 1838:23.
Habrobracon brevicornis (Wesmael). Cushman, 1922:122.
Microbracon brevicornis (Wesmael). Muesebeck, 1925:33.

Diagnosis.—Length of body, 2–3 mm. Color: Mostly black with yellow markings on head, prothorax, mesonotum, and venter of abdomen, abdomen occasionally entirely yellow, legs brown with coxae black, wings infuscate on basal ½. Body: Vertex and frons granular, rest of head smooth; thorax smooth and shining; abdomen finely granular and shining; antenna 16- to 19-segmented in female, 20- to 27-segmented in male; circular opening present between clypeus and mandibles (as in Fig. 1); occipital carina absent; ovipositor about as long as abdominal terga 2 and 3 combined. Wing: Fore wing venation as in Fig. 8.

Distribution.—Europe, Asia, Africa. Introduced into the United States and Canada but not established.

Hosts.—This species has a long list of hosts. It was purposely introduced into this country in the 1930's against *Ostrinia nubilalis* and subsequently against *Pectinophora gossypiella*, *Heliothis zea*, and *H. virescens*. No recoveries have been made.

Comments.—This species is a common parasite of the European corn borer and does not appear to be important in the control of *Heliothis* spp. There is still some question whether *Bracon brevicornis* and *B. hebetor* are distinct species, but that is beyond the scope of this paper.

Bracon platynotae (Cushman)

Habrobracon platynotae Cushman, 1914:104.
Bracon platynotae (Cushman). Muesebeck and Walkley, 1951:167.

Diagnosis.—Length of body, 2–3 mm. Color: Head and thorax black, face marked with yellow; abdomen and legs varying from entirely black to entirely honey yellow, wings dusky on basal ½, veins and stigma brown. Body: Entire body granular; ocelli small, ocellocular distance about 2× diameter of lateral ocellus; circular opening present between clypeus and mandibles (Fig. 1); occipital carina absent; antenna 22- to 27-segmented, segments longer than wide; ovipositor about ½ as long as abdomen. Wing: Fore wing venation as in Fig. 10.

Distribution.—Arizona, southern California, Georgia, Louisiana, Texas; Mexico.

Hosts.—Heliothis zea, Lineodes integer, L. interruptus, Pectinophora gossypiella, Pilemia periusalis, Platynota stultana.

Comments.—This is a common parasite of the pink bollworm and only rarely has been reared from *Heliothis* spp.

Bracon kirkpatricki (Wilkinson)

This species is a primary parasite of *Pectinophora gossypiella*, but I have seen one reference to it as a parasite of the bollworm (Bryan et al., 1973). If *kirkpatricki* does attack *Heliothis*, it apparently does so at such a low rate as to be insignificant. Further studies should be made to establish the relationship between *kirkpatricki* and *Heliothis*.

Genus *Cardiochiles* Nees

The North American species of *Cardiochiles* can be identified by Mao's (1949) key. Mao (1945) provides a key to the Mexican species; Fischer (1958), Egyptian species; Telenga (1955), Russian species; De Saeger (1948), Belgian Congo species.

Cardiochiles nigriceps Viereck

Cardiochiles nigriceps Viereck, 1912b:578.

Diagnosis.—Length of body, 6–8 mm. Color: Head and antenna black, thorax with venter and propodeum always black, scutellum and mesonotum posteriorly always orange, pronotum dorsally, mesonotum anteriorly, mesopleuron dorsally varying from black to orange, abdomen orange, fore and mid legs black, tibiae and tarsi sometimes brown, hind coxa and trochanters black, hind femur orange, hind tibia orange or brown, hind tarsus brown, wings strongly infuscated. Body: Head broad, transverse, temples bulging; body smooth and shining except propodeum which is strongly rugose with distinctly margined diamond-shaped areola in middle; hind femur swollen; ovipositor short and barely exerted. Wing: Fore wing venation as in Fig. 12, radius strongly arched, 1st intercubitus distinctly angulate below middle.

This species is not likely to be confused with other North American species; its body color and angled first intercubitus of the fore wing are distinctive.

Distribution.—District of Columbia south to Florida, west to Kansas and Louisiana; Mexico. Also introduced into the Philippines but apparently not established.

Hosts.—Heliothis subflexa, H. virescens. Also recorded on *H. assulta* in the Philippines.

Additional references.—Chamberlin and Tenhet (1926), Lewis and Brazel (1966), Vinson and Lewis (1965), Lewis et al. (1967), Lewis and Vinson (1968a, 1968b), Vinson (1968, 1969), Lewis and Vinson (1971), Hays and Vinson (1971), Vinson (1972), Lewis et al. (1972).

Comments.—This is the most important and most studied braconid attacking *Heliothis.* However, it seems to be restricted to *H. virescens.* There is only one record of it developing on *H. subflexa* (Lewis et al., 1967). It will attack *H. zea* but will not complete its development.

Genus *Chelonus* Panzer

There are no keys to North American species of *Chelonus* (in the strict sense); McComb (1968 (1967)) provides a key to the species of the subgenus *Microchelonus* for North America; De Saeger (1948) provides keys for species of both subgenera in the Belgian Congo.

Chelonus (*Microchelonus*) *heliope* Gupta

Chelonus heliope Gupta, 1955:209.
Chelonus (*Microchelonus*) *heliope* Gupta. McComb, 1968(1967):71.

Diagnosis.—Length of body, 3–4 mm. Color: Body black, scape yellow, basal flagellomeres brown, apical ones black, basal ⅓ of abdominal carapace yellow, fore and mid legs honey yellow except coxae and last tarsal segment which are black or brown, hind coxa black, hind trochanters brown, hind femur black, hind tibia black on apical and basal ⅓ with middle ⅓ yellow, hind tarsus yellow except last tarsal segment which is black. Body: Strongly sculptured; antenna of female 16-segmented, male 24- to 26-segmented; propodeum with strong tubercles at apical corners; 1st 3 abdominal terga fused into a strongly sclerotized carapace which encloses rest of abdominal segments, apex of abdominal carapace in male with deep transverse groove and tubercle in center of groove (Fig 4). Wing: Fore wing venation as in Fig. 9.

This species is somewhat similar to *pectinophorae* Cushman and *blackburni* Cameron, both of which have been introduced but not established, but it differs by having all flagellomeres at least slightly broader than long and in having the wing entirely hyaline. It is also similar to the endemic *fulgidus* McComb and *shenefelti* McComb but differs from both in having a shorter malar space which is equal to the basal width of the mandible.

Distribution.—India. Introduced into Arizona, Florida, Mississippi, New Jersey, North Carolina, South Carolina, Tennessee, and Texas but not established.

Hosts.—Symmetrischema heliopum, Pectinophora gossypiella, Corcyra cephalonica (in laboratory). Also introduced against *Heliothis zea, H. virescens,* and *Diatraea saccharalis* but not established.

Additional references.—Charpentier (1956, 1958), McGough and Noble (1957), Patel et al. (1958).

Comments.—This species was introduced in the United States mainly for control of the pink bollworm, but some introductions were also made against *Heliothis.* It has not been established and appears not to be an important parasite of *Heliothis.*

Chelonus (*Chelonus*) *insularis* Cresson

Chelonus insularis Cresson, 1865:61.
Chelonus texanus Cresson, 1872:179. New synonymy.
Chelonus texanoides Viereck, 1905:286. New synonymy.
Chelonus exogyrus Viereck, 1905:287. New synonymy.
Chelonus bipustulatus Viereck, 1911b:476. New synonymy.

Diagnosis.—Length of body, 4.5–5.0 mm. Color: Black, abdominal carapace usually with 2 white lateral spots on basal ⅓, carapace rarely entirely black or entirely orange, fore and mid legs orange except coxae, base of femora and apical tarsal segments which are black, hind coxa black, hind femur usually black, occasionally orange, hind tibia orange with base and apex black, wings lightly infuscated, stigma and parastigma black, veins brown or light brown near base of wing. Body: Entirely, strongly sculptured, sculpture rugose but not regularly areolated; antenna 26- to 32-segmented; propodeum with strong tubercles at apical corners; 1st 3 abdominal terga fused into a rigid dorsal carapace which encloses rest of abdominal segments, apex of carapace of male without groove or impression. Wing: Fore wing venation as in Fig. 13.

This species is similar to *narayani* but can be distinguished by the black parastigma, mostly orange hind femur, hyaline wings, and white spots at base of the carapace. I have seen the type of *insularis* Cresson and there is no doubt that it is the same as *texanus* Cresson.

Distribution.—North America, Central America, South America, West Indies. Introduced into Hawaii and South Africa.

Hosts (for North America).—Ephestia elutella, Feltia subterranea, Heliothis zea, Loxostege sticticalis, Peridroma saucia, Spodoptera eridania, S. exigua, S. frugiperda, S. ornithogalli, S. praefica, Trichoplusia ni.

Additional references (selected for *Heliothis*).—Pierce and Holloway (1912), Wolcott (1951 (1948)), Ullyett (1949), Botrell et al. (1968), Vinson (1975).

Comments.—This species, which occurs throughout the New World, is one of the common native species of *Heliothis* parasites, though it has been more often studied with *Spodoptera frugiperda.*

Chelonus (*Chelonus*) *narayani* Subba Rao

Chelonus narayani Subba Rao, 1955:63.

Diagnosis.—Length of body, 3.5–4.5 mm. Color: Black, all coxae, trochanters and femora black except apex of fore and mid femora which are occasionally orange, fore tibia and basitarsus orange, rest of fore tarsus brown, mid tibia brown at apex and base, yellow in middle, mid basitarsus yellow, rest of mid tarsus brown, hind tibia black at apex and base, yellow in middle, hind basitarsus yellow, rest of hind tarsus brown, fore wings hyaline on basal ½, strongly infuscate on apical ½, stigma black, parastigma yellow, abdominal carapace very rarely with weak orange spots at base. Body: Strongly sculptured, face and thorax appearing areolated; antenna 24- to 29-segmented; propodeum with strong spines at apical corners; 1st 3 abdominal terga fused into rigid dorsal carapace, apex of male carapace without groove or impression. Wing: Fore wing venation as in Fig. 11.

This species is similar to *insularis* but can be distinguished by the yellow parastigma and infuscate apex of the fore wing, the black hind femur, the totally black abdominal carapace, and the more areolated sculpturing of the face and thorax. It is also similar to *iridescens* Cresson but is smaller, has a relatively shorter carapace, and has the sculpturing more areolated on the face and thorax.

Distribution.—India. Introduced into Arizona, Florida, Louisiana, Mississippi, New Jersey, North Carolina, Pennsylvania, South Carolina, Tennessee, Texas, and Utah but not established.

Hosts.—*Heliothis armiger, H. zea, Chilo zonellus, Corcyra cephalonica* (in laboratory). Also introduced into Texas against *Pectinophora gossypiella*, into Pennsylvania against *Papaipema nebris*, into Louisiana against *Diatraea saccharalis* and *Chilo plejadellus*, and into Utah against *Phthorimaea operculella* but also not established.

Comments.—This is apparently a good species on *Heliothis* and more studies should be made to determine its effectiveness in North America.

Chelonus (*Microchelonus*) *blackburni* Cameron

This species was introduced into the United States against *Pectinophora gossypiella* but did not become established. According to Bryan et al. (1973), this species "*could* (italics mine) parasitize" *Heliothis zea* and *H. virescens*. Further field studies must be made to determine whether it will attack *Heliothis*.

Chelonus (*Chelonus*) *gossypii* Viereck

This species is not included in the key. It was described (Viereck, 1912a) from Brazil as a parasite "on cotton worm." If this refers to *Heliothis*, then *gossypii* is a possible additional parasite to be considered.

Genus *Meteorus* Haliday

The only key to North American species is that of Muesebeck (1923); Nixon (1943) provides a key to the Ethiopian species.

Meteorus autographae Muesebeck

Meteorus autographae Muesebeck, 1923:30.

Diagnosis.—Length of body, 4–5 mm. Color: Female usually entirely honey yellow, sometimes mesonotum, propodeum and 1st abdominal segment (petiole) dark brown, male usually honey yellow with vertex, mesonotum, propodeum, and all abdominal terga except the 2nd dark brown, stigma uniformly pale yellow, transparent. Body: Eyes large; ocelli large, ocellocular distance about 2× diameter of lateral ocellus; mesonotal lobes smooth; ventral margins of petiole meeting beyond base of petiole and touching for only a short distance (Fig. 20). Wing: Fore wing venation as in Fig. 15, 1st segment of radius at most ½ as long as 2nd segment, recurrent vein entering base of 2nd cubital cell.

This species is very similar to *laphygmae* but is distinguished by the ventral margins of the petiole and the wing venation.

Distribution.—Newfoundland south to Florida, west to Ontario and Louisiana.

Hosts.—Many species of Noctuidae but primarily a parasite of *Spodoptera frugiperda.*

Comments.—This is not an important parasite of *Heliothis.* I have seen only one specimen reared from *Heliothis zea.*

Meteorus laphygmae Viereck

Meteorus laphygmae Viereck, 1913:560.

Diagnosis.—Length of body, 3.5–5.0 mm. Color: Entirely honey yellow, rarely petiole with black markings at apex. Body: Eyes large; ocelli large, ocellocular distance about equal to diameter of lateral ocellus; mesonotal lobes weakly punctate; ventral margins of petiole meeting at base of petiole and touching for nearly ½ the length of petiole (Fig. 19). Wing: 1st segment of radius of fore wing nearly as long as 2nd segment, recurrent vein interstitial with 1st intercubitus.

Distribution.—Texas and New Mexico south to northern South America; introduced into Hawaii.

Hosts.—Autographa sp., *Colias eurythene, Elaphria nucicolora, Feltia subterranea, Heliothis zea, Leucania latiuscula, Peridroma saucia, Pseudaletia unipuncta, Semiothisa punctolineata, Spodoptera eridania, S. exigua, S. frugiperda.*

Comments.—This species is occasionally reared from *Heliothis* species though it has been studied most frequently as a parasite of the fall armyworm.

Genus *Microplitis* Foerster

Muesebeck (1922) provides a key to the North American species; Wilkinson (1930), Indo-Australian species; Telenga (1955), Russian species; Nixon (1970), northwestern European species.

Microplitis croceipes (Cresson)

Microgaster croceipes Cresson, 1872:183.
Microplitis nigripennis Ashmead. *In* Quaintance and Brues, 1905:122.

Diagnosis.—Length of body, 3.5–4.5 mm. Color: Head, antenna, and thorax black, abdomen usually orange, rarely black, legs orange except coxae which are black, wings strongly and entirely infuscated. Body: Very smooth and shining; propodeum coarsely rugose with median longitudinal carina; 1st abdominal tergum weakly punctate along edges; temples bulging beyond eye margins; hind femur short and stout, not more than 3× as long as greatest width; ovipositor barely exerted. Wing: Fore wing venation as in Fig. 14.

This species and *longicaudus* are distinct from all other *Microplitis* in North America by their smooth and shining head and thorax and short and stout hind femur. From *longicaudus* this species is distinguished by the shorter ovipositor and infumated wings.

Distribution.—New Jersey south to Georgia, west to Utah and Arizona; Oregon. Probably also occurs in northern Mexico.

Hosts.—Heliothis subflexus, H. virescens, H. zea.

Additional references.—Bryan et al. (1969), Lewis (1970), Jones and Lewis (1971).

Comments.—This is one of the more important parasites of *Heliothis* species. It has not been reared from any hosts other than those listed. D. E. Bryan (personal communication) has indicated that biological data presented by Bryan et al. (1969) and Jones and Lewis (1971) do not agree in all respects with the indication that *croceipes* of the eastern United States may not be the same as the western forms. Further study is needed to clarify this matter.

Microplitis indica Marsh, new species

Description.—Length of body, 2.5 mm. Color: Head including antenna and thorax black, abdominal terga 1–4 in female and 1–3 in male orange, rest black, 1st abdominal tergum of male sometimes darker, legs of female orange except tarsi always and hind coxa occasionally black, legs of male orange except coxae and tarsi which are black, tegula orange, wings evenly infumated, veins brown, stigma brown with yellow spot at basal ⅓. Body: Head distinctly punctate, dull; antenna 18-segmented and longer than body in male; mesonotum distinctly punctate and dull; notauli not impressed and only weakly indicated by confluent punctures along their course; scutellum dull, punctate, scutellar furrow wide and deep with 3–5 carinae; mesopleuron strongly punctate except smooth shining area above the crenulate sternaulus; propodeum strongly rugose with weak indication of median carina; 1st abdominal tergum as long as greatest width, parallel sided for ⅔ its length, narrowing on apical ⅓, finely rugose laterally, smooth apically; ovipositor sheaths barely exerted, hypopygium not extending beyond apex of abdomen; hind tibial spurs equal in length. Wing: Fore wing venation as in Fig. 16.

This species is similar to *pallidipes* Szepligeti which occurs in southeast Asia but differs by the darker tarsi and antennae, less distinct notauli, and weakly indicated median carina on the propodeum. It is also similar to *rufiventris* Kokujev that occurs in southern Russia (Uzbeck, Turkmen), but it can be distinguished by the black tip of the abdomen and black tarsi. In North America, *indicus* runs to *laticinctus* or *bradleyi* in Muesebeck's (1922) key but is distinguished from *laticinctus* by its less sculptured first abdominal tergum and black antennae and from *bradleyi* by its orange abdominal terga 1–4. It might also be confused with *melianae* but is distinguished by its yellow tegula, orange abdominal terga 1–4, narrower and more rugose first abdominal tergum, and infumated wings.

Holotype female.—Kulu, India; lab. reared; Ship't., no. 5, IX-64; ex *Heliothis* sp. Paratypes, 2♀, 2♂, same data as type. All types deposited in USNM.

Distribution.—India.

Host.—Heliothis assulta.

Comments.—This species was originally determined as *Apanteles* sp. and later as *Microplitis* sp. near *pallidipes.* It was reared in laboratories in New Jersey and Georgia but never released.

Microplitis melianae Viereck

Microplitis melianae Viereck, 1911a:185.

Diagnosis.—Length of body, 2.5–3.0 mm. Color: Head, thorax and abdomen black, tegula brown, abdominal terga 1 and 2 brown laterally and ventrally, coxae and trochanters black or brown, rest of legs yellow, tarsi brown in male, wings hyaline, stigma with basal ½ yellow, rest brown. Body: Head and thorax coarsely punctate and dull; mesopleuron smooth and shining; propodeum rugose with distinct median carina; abdominal terga smooth and shining, 1st abdominal tergum usually punctate at apex; ovipositor barely exerted.

This species might be confused with *indicus* if that species were to be established in North America, but *melianae* is distinguished by its darker tegula and abdomen, hyaline wings, and smoother abdomen.

Distribution.—Illinois, Iowa, Kansas, Michigan, Minnesota, New York, Ohio, Ontario, Tennessee.

Hosts.—Faronta diffusa, Heliothis zea, Pseudaletia unipuncta.

Comments.—This species is a frequent parasite of the armyworm, but there is at least one record from *Heliothis zea.* It is not considered an important parasite of *Heliothis.*

Genus *Rogas* Nees

The only reliable keys to species are Telenga (1941) for Russia, Fahringer (1931) for Europe, and Gránger (1949) for Madagascar.

Rogas perplexus Gahan

Rogas perplexus Gahan, 1917:205.

Diagnosis.—Length of body, 4–5 mm. Color: Mostly brown with the following parts honey yellow, vertex, orbits around eyes, face occasionally,

Table 1. Records of Old World Braconidae parasitic on *Heliothis* spp.

Parasite Species	Host Species	Locality	Reference
Apanteles difficilis	obsoletus	Russia	Telenga, 1937, 1955
Apanteles kazak	obsoletus	Southern Russia	Telenga, 1955; Bogush, 1957
Apanteles popularis	obsoletus	Southern Russia	Bogush, 1957
Apanteles ruficrus	armiger	India	Beeson & Chatterjee, 1925; Bhatnagar, 1950
	obsoletus	Australia	Wilkinson, 1929
		Fiji	Lever, 1941
		Egypt	Hafez, 1947
		Russia	Telenga, 1955
Apanteles maculitarsis	armiger	South Africa	Parsons, 1940
Bracon simonovi	armiger	Southern Russia	Bogush, 1957
	obsoletus	Southern Russia	Bogush, 1957
Bracon turkestanicus (=hebetor)	obsoletus	Southern Russia	Bogush, 1957
Cardiochiles trimaculatus	armiger	Uganda	Coaker, 1959
Cardiochiles nigricollis	armiger	South Africa	Parsons, 1940
Chelonus curvimaculatus	armiger	South Africa	Parsons, 1940; Coaker, 1959
Chelonus versatilis	obsoletus	Sudan	Wilkinson, 1932b
Meteorus laphygmarum	obsoletus	Sudan	Nixon, 1943
		Uganda	Coaker, 1959
Microplitis demolitor	obsoletus	Australia	Smith, 1945
		Egypt (intro.)	Hafez, 1951
Microplitis rufiventris	obsoletus	Russia, Rumania	Telenga, 1937
Microplitis pallidicornis	dipsaceus (=viriplacus)	Russia	Telenga, 1937
Rogas aestuosus	peltiger	Russia, Cyprus, Syria	Telenga, 1937, 1941
Rogas dimidiatus	obsoletus	Europe	Bogush, 1959; Stary, 1958
Rogas nocturnus	obsoletus	Southern Russia	Bogush, 1957
Rogas testaceus	obsoletus	Southern Russia	Bogush, 1957; Stary, 1958
Rogas armatus	ononis	Europe	Telenga, 1941; Fahringer, 1932

along lines of notauli on mesonotum, scutellum, apex of 1st abdominal tergum, and all of terga 2 and 3, and all legs; wings hyaline, veins brown, stigma brown with base and apex yellow. Body: Entire body granular; eyes and ocelli large, ocellocular distance about equal to diameter of lateral ocellus; circular opening present between clypeus and mandibles (similar to Fig. 1); occipital carina present; abdomen with median longitudinal carina along terga 1–3; ovipositor barely exerted. Wing: Fore wing venation as in Fig. 7.

Distribution.—Arizona, southern California, New Mexico, Texas.

Hosts.—*Heliothis zea*, *Peridroma saucia*, *Trichoplusia ni.*

Additional references.—Butler (1958), rearing records.

Comments.—Pupation of species in this genus takes place within the mummified host larva, which retains its shape. This is an uncommon species and insignificant as a parasite of *Heliothis.*

Old World Records of Braconidae Parasitic on *Heliothis* Species

Table 1 lists Braconidae from the Old World that have been recorded as parasites of *Heliothis* species. This is not an exhaustive list of all records that I have seen but represents what I believe to be the most reliable records. In many of the records there is no biological information other than a rearing record. Some of the records are undoubtedly incorrect; others indicate some species are occasional parasites of *Heliothis.* These records are presented to indicate potential species of interest and/or areas where parasites might be collected in the future.

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Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

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TACHINID PARASITES OF *HELIOTHIS* IN THE WESTERN HEMISPHERE (DIPTERA; LEPIDOPTERA)

Curtis W. Sabrosky

Abstract.—Search of the literature and personal records of identifications yielded a total of 61 species of Tachinidae recorded from *Heliothis* in the Western Hemisphere, plus 3 species recently introduced from India but not yet known to be established. The table includes the geographic region, the species of *Heliothis* involved (*H. zea*, *H. virescens*, "others, or sp."), and a brief summary of the known host relationships of the tachinids. Many of the species are uncommon, or at least rarely reared. Almost all the common species are polyphagous, especially on Noctuidae.

I present here a preliminary list of tachinid flies known to parasitize species of the noctuid genus *Heliothis* in the Western Hemisphere. It is probably complete for the major parasites because much attention has been and is being given to parasites of *Heliothis*, but minor, occasional, aberrant, or rare species of parasites will undoubtedly be added in the future. The present list is based on card catalogs in the Systematic Entomology Laboratory, my personal records of identifications, the manuscript of "A Host-Parasite Catalog of North American Tachinidae" by Paul H. Arnaud, Jr., soon to be published by the U.S. Department of Agriculture, and the recently published "Host-Parasite and Parasite-Host Catalogue of South American Tachinidae (Diptera)" by J. H. Guimaraes (1977, Arq. Zool, Sao Paulo, 28(3):1–131). For commonly reared species, host relations are summarized from the available information. Many of the tachinids are uncommon or at least rarely reared. Almost all of the common species are polyphagous, especially on Noctuidae.

Abbreviations: NA = North America, SA = South America, WI = West Indies; * = personal identification; ** = both personal identification and published records.

Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

Table 1.

Geog. region	Species of tachinid	*Heliothis*			Host relations and notes
		zea	*virescens*	others, or sp.	
SA	*Actinoplagia koehleri* Blanch.	x(**)		*H. gelotopoeus* and spp.	Argentina, Chile, Uruguay; recorded only from *Heliothis*.
SA	*Archytas incertus* (Macq.)	x	x	*H. gelotopoeus* and spp. (*)	Argentina, Brazil, Uruguay; recorded from 5 noctuid genera, an arctiid, and a pierid.
NA, WI, SA	*A. marmoratus* (Tns.)	x(**)	x(**)	*H.* sp. (n. Chile)	Polyphagous, Noctuidae; many published records.
SA	*A. platonicus* Cortés & Campos	x			1 record, Peru.
SA	*A. scutellatus* (Macq.)	x			Chile; recorded from 2 noctuids.
SA	*Ateloglutus chilensis* (Brèthes)	x		*H.* spp.	Chile.
NA	*Athanatus californicus* (Coq.)			*H. ononis*	Rare sp., 1 record, w. Canada.
NA	*Athrycia cinerea* (Coq.)	x(*)			Parasitic chiefly on *Pseudaletia unipuncta*.
NA	*Bonnetia comta* (Fall.)	x(*)			Polyphagous on noctuids.
	Carcelia illota (Curran)	x(lab.)	x(lab.)		First described, Africa; introduced USA from India; released Ga., Ariz.
SA	*Celatoriopsis eucelatorioides* Blanch.			*H. gelotopoeus*	1 record, Argentina.
SA	*Chaetocnephalia americana* (Schin.)			*H.* spp.	Argentina, Chile.
NA	*Chaetogaedia analis* (Wulp)	x			3 published records, 1 each from Arctiidae, Geometridae, Noctuidae.
NA	*C.* sp. near *analis*			*H.* spp.	1 record, Ariz.
SA	*C. aurata* Blanch.			*H. gelotopoeus*	1 record, Argentina.
NA	*C. monticola* (Bigot)	x(**)	x		Highly polyphagous, chiefly Noctuidae; Hawaii on *virescens*.

Table. 1. Continued.

Geog. region	Species of tachinid	*Heliothis*			Host relations and notes
		zea	*virescens*	others, or sp.	
NA	*Compsilura concinnata* (Mg.)	x(*)			Highly polyphagous; 1 on *zea*, N.J.
NA	*Eucelatoria armigera* (Coq.)	x(**)		*H. hawaiiensis*	Polyphagous, chiefly Noctuidae; many publ. records on *zea*, some confused with sp. near *armigera*.
NA	*E.* sp. near *armigera*	x(**)	x(*)	*H. phloxiphagus* (lab.)	Polyphagous, chiefly Noctuidae; Tex. and Ariz. records.
SA	*E. australis* Tns.	x	x	*H.* spp. (Chile) (*)	Cuba and P.R. records chiefly on *Leucania latiuscula*; on *H. virescens* in Peru, on *zea* in Chile.
NA	*E.* n. sp.	x(*)			Mexico.
NA	*E. rubentis* (Coq.)	x(*)	x(or *zea*?) (*)		Few records, chiefly on armyworms.
NA	*Eusisyropa blanda* (Coq.)	x(*)			Highly polyphagous; 1 record on *zea*, Del.
NA	*Exorista mella* (Walk.)	x			Polyphagous.
	E. xanthaspis (Wied.)		x		Palearctic species; introduced from India as *E. fallax*; released Ga.
SA	*Gonia pallens* Wd.			*H.* spp.	Chile; recorded from 2 other genera of noctuids.
NA	*Gonia* sp. or spp.	x			*Gonia* species are polyphagous, almost entirely on Noctuidae; 2 records on *zea*, Tex. and Calif.

Table 1. Continued.

Geog. region	Species of tachinid	*Heliothis*			Host relations and notes
		zea	*virescens*	others, or sp.	
WI	*Gymnochaetopsis fulvicauda* (Walton)	x			Chiefly par. of the noctuid *Mocis repanda,* in P.R. and Jamaica; 1 record on *zea,* Jamaica.
NA	*Hyphantrophaga hyphantriae* (Tns.)	x			Highly polyphagous, only 2 noctuids; 1 record on *zea,* Tex., 1905.
SA	*Incamyia charlini* Cortés	x			Chile.
SA	*I. chilensis* Ald.			*H. gelotopoeus* and spp.	Polyphagous, chiefly on Noctuidae; Argentina, Chile.
SA	*I. spinicosta* Ald.	x		*H.* spp.	Argentina, Chile.
NA	*Leschenaultia adusta* (Lw.)	x(lab.)			Polyphagous, chiefly on Arctiidae; on *zea,* lab. Ariz.
NA	*Lespesia aletiae* (Riley)	x(**)	x(*)		Highly polyphagous; common on *Heliothis*; many publ. records.
NA	*L. archippivora* (Riley)	x(**)		*H. hawaiiensis*	Highly polyphagous; many publ. records.
NA	*L. frenchii* (Will.)	x			Highly polyphagous; only 3 records on *zea.*
SA	*L. nimia* Cortés & Campos			*H.* sp.	1 record, Chile.
SA	*L. rufomaculata* (Blanch.)			*H. gelotopoeus*	1 record, Argentina.
NA	*Metaplagia occidentalis* Coq.	x	x		Few records: 4 on *Heliothis,* 2 on Sphingidae.
NA	*Metavoria orientalis* Tns.	x(*)			Few records, and those on Sphingidae (*Manduca*).

Table 1. Continued.

Geog. region	Species of tachinid	*Heliothis*			Host relations and notes
		zea	*virescens*	others, or sp.	
SA	*Myiosturmia mixta* Tns.		x		Brazil; also recorded from *Mocis latipes.*
NA, WI	*Nemorilla pyste* (Walk.)	x			Highly polyphagous, especially on Microlepidoptera. One record on *zea*, Virgin Islands.
	Palexorista laxa (Curran)	x(**) (lab.)	x(*) (lab.)		First described, Africa; introduced USA from India; released Ga., Ariz.
SA	*Patelloa similis* (Tns.)			*H. gelotopoeus*	Polyphagous on Noctuidae; ex *Heliothis* in Argentina.
SA	*Peleteria pygmaea* (Macq.)	x		*H.* spp.	Argentina, Brazil, Chile; recorded from 2 noctuid genera.
NA	*Phryxe pecosensis* (Tns.)			*H. phloxiphagus*	Polyphagous; *Heliothis* record in Wash.
NA	*P. vulgaris* (Fall.)			*H. phloxiphagus*	Polyphagous; *Heliothis* record in Wash.
NA	*Plagiomima cognata* Ald.			*H.* spp.	1 record, Ariz.
NA	*P. spinosula* (Bigot)	x(*)		*H.* spp. (**)	1 record, Okla.
SA	*Protypophaemyia townsendi* Blanch.			*H. gelotopoeus*	Argentina; recorded from 2 noctuid genera.
NA	*Siphona plusiae* Coq.	x(*)			Few records, mostly Noctuidae; my det. from Calif.
SA	*Spoggosia caridei* (Brèthes)			*H. gelotopoeus*	Polyphagous, on at least 6 families.

Table 1. Continued.

Geog. region	Species of tachinid	*Heliothis*			Host relations and notes
		zea	*virescens*	others, or sp.	
NA	S. *claripennis* (Macq.) (*Euphorocera* of Catalog)	x	x		Highly polyphagous.
NA	S. *floridensis* (Tns.)	x(**)	x(*)		Highly polyphagous; on numerous families.
SA	S. "*floridensis* (Tns.)"			*H.* spp.	Polyphagous on several families.
NA	S. *omissa* (Rein.)	x		*H.* spp.	Few records (3 of 5 are Noctuidae); "spp." Okla.
SA	S. *peruviana* (Tns.)		x		From 2 genera of noctuids; Peru.
NA	S. *tachinomoides* (Tns.)	x(*)		*H.* spp.	"spp." Okla.
NA	*Voria ruralis* (Fall.)	x			Polyphagous on Noctuidae; normally par. on *Trichoplusia ni*; *zea* record, Okla.
SA	*Winthemia ignobilis* (Wulp)			*H.* spp.	Chile.
NA	*W. quadripustulata* (F.), of North American authors				Highly polyphagous, commonly on Noctuidae; many publ. records.
NA	*W. rufopicta* (Bigot)	x(**)	x(*)		Highly polyphagous, especially on Noctuidae; common sp.
NA	*W. sinuata* Rein.			*zea* or *virescens* (*)	Polyphagous; common.
NA	*W.* sp. (? *occidentis* Rein.)	x(*)			Del.

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WHAT IS SYSTEMATIC ENTOMOLOGY?[1]

George C. Steyskal

Abstract.—Systematic entomology is defined and its position as the basic regimen of entomology is discussed. Systematics is indispensable as it serves the general need, biological control problems, ecological and environmental studies, veterinary entomology, etc. Examples of the difficulties and rewards for the systematic entomologist are given.

Most systematic entomologists have at least a fairly good idea of the aims and content of their branch of science, but among laymen and even scientists of physical and chemical disciplines there is some misapprehension. Some scientists believe that systematic entomology is not even a science, apparently because it does not ordinarily require a laboratory filled with expensive and complex apparatus and because, again ordinarily, controlled experiments are not performed. However, systematic entomology is indeed not only a science but the basic regimen of entomology.

Let us define our terms. The "preliminary definition" of *science* by Caws (1965:11) should suffice for our purpose, inasmuch as it is in the restricted sense we require and is even more philosophically rigorous than the dictionary definitions, while at the same time in agreement with them: "science is the explanation of nature on its own terms, together with all that follows from doing that successfully, such as the ability to predict how things will behave and hence to control them." Caws' 354-page book, entitled "The Philosophy of Science, a Systematic Account," is a commentary on this definition.

The word *research* is defined in the scientific sense in the great *Oxford Dictionary* as "a search or investigation directed to the discovery of some fact by careful consideration or study of a subject; a course of critical or scientific inquiry." The *Third New International Dictionary of the English Language* (Webster's) is more prolix: "a studious inquiry or examination; *esp* critical and exhaustive investigation or experimentation having for its aim the discovery of new facts and their correct interpretation, the revision of accepted conclusions, theories, or laws in the light of newly discovered facts, or the practical application of such new or revised conclusions, theories, or laws." It is thus evident that controlled experimentation is not a necessary part of research in its broad sense, but that hypothesis and testing in some form, even when the latter is not feasible by direct experimentation, definitely are.

The definition of *systematic* is not quite so easy. The word is an adjective on which the noun *systematics* is based. These words are in turn derived from the noun *system*, which is merely a way of referring to the fact that in science the various parts of the study of a subject agree with each other and hang together in a cohesive whole. Science, after all, is only a systematic way of considering nature.

Systematics is also known as taxonomy. A distinction is often made between these two terms, but in general they are virtually synonymous. The dictionaries define both as "the science of classification" and cite them as synonyms of each other. The term *classification*, however, when narrowed to its meaning in biology, is too narrow and entails unfortunate connotations carried over from its use in non-biological fields.

Let us, therefore, refer to a few texts on systematics (or taxonomy) published since 1960, viz. Simpson (1961), Cain (1963), Hennig (1966), Blackwelder (1967), Mayr (1969), Michener (1970), and Ross (1974). There is much more in the literature referring to the basics of zoological science, but these works can be considered representative and authoritative enough to use in drawing conclusions.

Simpson (1961) says that "systematics is the scientific study of the kinds and diversity of organisms and all relationships among them." He also quotes Hennig's Grundzüge der phylogenetischen Systematik (1950), the precursor of his revised work published in English in 1966, ". . . one must first make clear that there is a systematics not only in biology, but that it constitutes an integrating component in any science whatsoever."

Cain (1963): "In recent years it has been gradually realized that taxonomy is not merely a necessary pigeon-holing but also one of the most important activities in biology, requiring a synthesis of all other biological pursuits for its proper performance . . . ."

Hennig (1966) states, ". . . systematics in the most general sense is equivalent to order, rationalization, and in a certain context explanation of the world of phenomena; and . . . in this sense systematics is a very broad task of all natural sciences, and particularly of all biological disciplines," and at another place, ". . . systematics fundamentally means any investigation of relations between natural things and natural processes insofar as they have the character of conformity to law."

Blackwelder (1967) gives a definition on the first page of his text: "Both taxonomy and classification, and all the other aspects of dealing with organisms and the data accumulated about them, are included in systematics, which is the general term that covers all aspects of the study of kinds. Therefore, systematics is the study of the kinds and diversity of organisms, their distinction, classification, and evoluton." He uses as a prefatory quotation the following sentence from Simpson (1945): "taxonomy is at the same time the most elementary and the most inclusive part of zoology, most elementary because animals cannot be discussed or treated in a scientific way until some taxonomy has been achieved, and the most inclusive because taxonomy in its various guises and branches eventually gathers together, utilizes, summarizes, and implements everything that is known about animals, whether morphological, physiological, psychological, or ecological."

Mayr (1969) follows Simpson (1961), already quoted, and distinguishes taxonomy as the "theory and practice of classifying organisms."

Ross (1974) considers that the term *taxonomy* is a synonym of systematics and that "systematics has the majority vote as the inclusive name to be applied to the total field of investigation that we are discussing." He uses the newer term "biosystematics . . . as the investigational field of systematics based on any scientific information that can be brought to bear on the problems of the evolution of species, whether they concern speciation or phylogeny." Inasmuch as systematics is not restricted to biology (see Hennig, 1950), the term *biosystematics* is nothing more than a restrictive term referring to systematics in biology, and is superfluous when used in purely biological context.

In a remarkably clear, balanced, and suggestive article on "Diverse Approaches to Systematics," Michener (1970) cites Simpson's definition of systematics. He also states, "one might think that this (Simpson's definition of systematics) includes everything in population biology . . . but the systematic approach is *less* broad" (my italics). I would consider that it is less broad only if it concerns a part of biosystematics, one dealing only with certain kinds of organisms. The systematics of all biology certainly must include population biology, at least as a source of data.

There is much agreement among these definitions. Sifting them out, one may come to the conclusions that 1) the term *systematics* is becoming accepted as the term including both taxonomy and classification, whether or not some synonymy is involved, and 2) systematics is becoming continually broader in scope, using ever more various ways of looking at organisms.

Systematics in biology is based upon two assumptions, 1) that all biological science is founded on the species concept, and 2) that all kinds of data are grist for its mill.

It is the basic concern of systematics to place the concept of an organism in proper relationship within the species concept—is it that of a species, subspecies, of a higher or lower taxonomic rank, and, establishing the rank, what relationships in time, space, and kind does it bear to those of other organisms, especially those closest to it?

The last few decades have seen the field of systematics expand enormously; some have even said that biology is changing from many more or less well-defined disciplines into one all-embracing subject. The concept of holomorphology was stressed by Hennig as early as 1950. Anything evenly remotely to be considered as morphological (even cell and chromosome structure), physiological characteristics (because organic chemicals are substances and have form), and proteins, all fall within the scope of morphology because they have form (*morphē*). The use of the genitalia of both sexes and their associated structures has now become commonplace, even considered necessary, in the study of any kind of insect. Internal structures are becoming increasingly important. Arnold (1972a, 1972b) has recently been pursuing the study of insect haemocytes with reference to systematics.

The proceedings of an international conference on systematic biology have been published in a volume (Internatl. Conf. Syst. Biol., 1969) that includes papers on systematics of populations, ecological aspects of systematics (in plants and animals), molecular data in systematics, systematic significance of isolating mechanisms, comparative animal behavior in systematics, comparative cytology in systematics, biometric techniques in systematics, and computer techniques in systematics. Mayr, in the opening paper in the volume, closes with the statements "Finally, let us remember that in virtually every taxonomic finding certain generalizations that are of value and broad interest to biology as a whole are implicit" and "It is my sincere belief that systematics is one of the most important and indispensable, one of the most active and exciting, and one of the most rewarding branches of biological science. I know of no other subject that teaches us more about the world we live in."

Edward O. Wilson, in the final paper summarizing that conference, asks, "What is a *pure* systematist? He might be defined as a biologist who works on such a large number of species that he has only time enough to consider classification and phylogeny. If he narrows his focus, his unique knowledge provides him with a good chance to make discoveries in genetics, ecology, behavior, and physiology. But then we come to know him as a geneticist, or an ecologist, or a behaviorist, or a physiologist. It clearly will not do to define systematics as classification plus all these other fields, because that would be robbing the discipline of its true meaning. I think it would be appropriate just to acknowledge everything that systematists do for the rest of biology (and that is a great deal indeed) . . . ." He also notes "It has occasionally been said that the perfect experimental biologist selects a problem first and then seeks the organism ideally suited to its solution. In contrast, the typical systematist selects the organism first —for the love of it. Now this is a great strength, for the systematist devotes his career to the organism and thereby often comes upon problems of general significance that would be discovered otherwise; . . ."

In a paper to be delivered at the BARC Symposium II, at the Beltsville Agricultural Research Center, on 8–11 May 1977, Foote (in press) has brought together an imposing list of references and much data on the importance of systematics to the general need, biological control problems, ecological and environmental studies, veterinary entomology, etc.

Mathematics and its offspring computer technology are becoming more and more used in systematics. Numerical taxonomy, which burst upon the scene with great eclat as a new solution to the problems of systematics, is now taking its more logical position as taxonomic mathematics. Mathematics, even of the most sophisticated kind, is still the handmaiden and not the director of the sciences.

Many new ways of working with insects are coming to hand, new ways of getting at them and new ways of looking at them. Electron microscopy is allowing entomologists to see things they never saw before. But entomologists, especially those practicing systematics, are too few and have too much to do to take full advantage of these new ways and means. The best solution of a problem is often too time-consuming and costly; the systematist must therefore be content in many instances with a solution that is merely good enough at the moment. Perhaps he may be able to do something better later. At the worst, other entomologists, some perhaps better situated, will find in more detail, discover new facts, and make new hypotheses sooner or later.

Heiser (1966) has remarked that the "process of character selection, rejection, and weighting by taxonomists is one of the great mysteries to some non-taxonomists and to beginning taxonomists . . . ." I would say that it is part of the taxonomist's way of experimenting, his process of hypothesizing, testing, and rehypothesizing repeated until a better hypothesis is found.

A systematic entomologist, then, studies all aspects of insect life by any feasible means in order to add to and correct or refine our knowledge concerning insects, and thereby advances the possibilities of dealing with them in the fields of prediction and control.

Let us now consider a few concrete examples, selected more or less fortuitously, to illustrate how the systematist works and what he does or may accomplish. It should not be forgotten, in considering these examples, that by far the greatest number of insects species have close relatives that are not easy to distinguish from them, although sometimes their habits may be quite different. Even entomologists who are not systematists often lose sight of this fact.

1) *The imported fire ants in the United States.*—For over 30 years it had been supposed that only 1 species of *Solenopsis*, perhaps with two varieties, had entered the United States. Buren (1970) showed that two distinct species, S. *richteri* Forel, 1909, and S. *invicta* Buren, 1970 are present, with little or no hybridizing. He was able to do this by careful analysis of larger amounts of material and comparing it with more South American material than others had before his study. He also was able to consider differences in the chemical constituency of the venoms of the two species. He was thus able to set up a new hypothesis concerning the systematics of the organisms, one that agrees better with additional observed data.

2) *North American species of* Rhagoletis *(Diptera: Tephritidae).*—Prob-

lems of the taxonomic status of morphologically very similar fruitflies feeding upon different hosts were largely solved in a revision of the North American species by Bush (1966), whose objective was "to incorporate as much . . . biological information as possible into a reevaluation of these so-called host races. Additional observations made in three years of field and laboratory work on such aspects as the problem of chromosome cytology, courtship behavior, distribution, and host relations have also been included." Chromosome morphology aided considerably in defining the genus. He also stated that "certain aspects in the adaption to new hosts, such as the genetics and chemistry of host selection, conditioning, and mating behavior, have yet to be studied. The hosts of several species are still unknown and the distribution of most species, including those of economic importance, is yet to be definitely established."

3) *The genus* Muscidifurax *(Hymenoptera: Pteromalidae).—Muscidifurax raptor* Girault and Saunders, 1910, a parasite of the house fly, *Musca domestica* L., was considered to be the sole species of its genus and to occur in the southwestern United States, tropical America, Europe, and Africa, until Kogan and Legner (1970) made reciprocal crossing experiments which showed that some of the populations were reproductively isolated and noted other biological differences. Their study revealed five species with several morphological differences, even in the eggs. Scanning electron microscopy proved helpful in working with these small insects, the largest of which is 2.8 mm long. Van den Assem and Povel (1973), in studying three of these species, found differences in courtship behavior sufficient to act as a barrier to crossmating, at least in sympatric species,

4) *Species of* Procecidochares *(Diptera: Tephritidae) forming galls on weeds of the genus* Ageratina.—In 1947, Stone described *Procecidochares utilis*, which was collected in Mexico, the original source of the weed *Ageratina adenophora*, and introduced into Hawaii for biological control of the weed. When a second species of the weed, *A. riparia*, also became troublesome in Hawaii, it was found that *Procecidochares utilis* would not use it as a host. A search was then made, again in Mexico, for gall-forming flies on *Ageratina riparia*. Another species of *Procecidochares* was found and brought to Hawaii, where it was found to refuse *Ageratina adenophora* as as host. Adults of the flies on *A. riparia* were referred to me for determination. At first I could find only a small, doubtful difference in the pattern of the wing between the two flies, but knowledge of the host specificity induced me to look further. Finally good morphological differences were found in postabdominal details of both sexes and in eggs removed from ovaries. I described the species as new (Steyskal, 1974).

These examples could be extended *ad nauseam*. Nothing has been said here about phylogeny and higher classification. The practicing systematist is usually not a pure systematist in the sense of Wilson because he does not have time for anything but classification and phylogeny, but because he must still deal with the species-distinction problems, what has been called "alpha" taxonomy. He usually hopes that someday he can do the big job, when the routine or teaching load permits. But even for the basic or elementary problems he must still be able to accumulte much material, often having to collect it himself; he must visit many museums; he should be able to rear his specimens; he should have the use of an electron scanning microscope; he should have computer time available; and he should have somebody to do some of the routine jobs, such as mounting specimens, making slides, keeping literature up-to-date, etc., etc., then perhaps he could do more and better primary systematics or even do large revisions, phylogenies, etc.

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Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv. USDA, c/o U.S. National Museum, Washington, D.C. 20560.

Footnote

[1] Address of retiring 1976 President, delivered at the Society meeting held on 3 February 1977.

Announcement

The Second International Working Conference on Stored-Product Entomology will be held in Ibadan, Nigeria, 10–16 September 1978 at the Conference Centre on the campus of the University of Ibadan.

The purpose of the Conference is to provide a forum for intellectual and practical discussions on current research and future research needs in the context of the World Food Economy.

For information, inquiries should be addressed to:

Organizers
Working Conference on Stored-Product Entomology
c/o Director, Institute of Agricultural Research and Training
P.M.B. 5029, Moor Plantation
Ibadan, Nigeria

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TWO NEW SPECIES OF *PHLEBOSOTERA* DUDA (DIPTERA: ASTEIIDAE) FROM NORTHERN NIGERIA

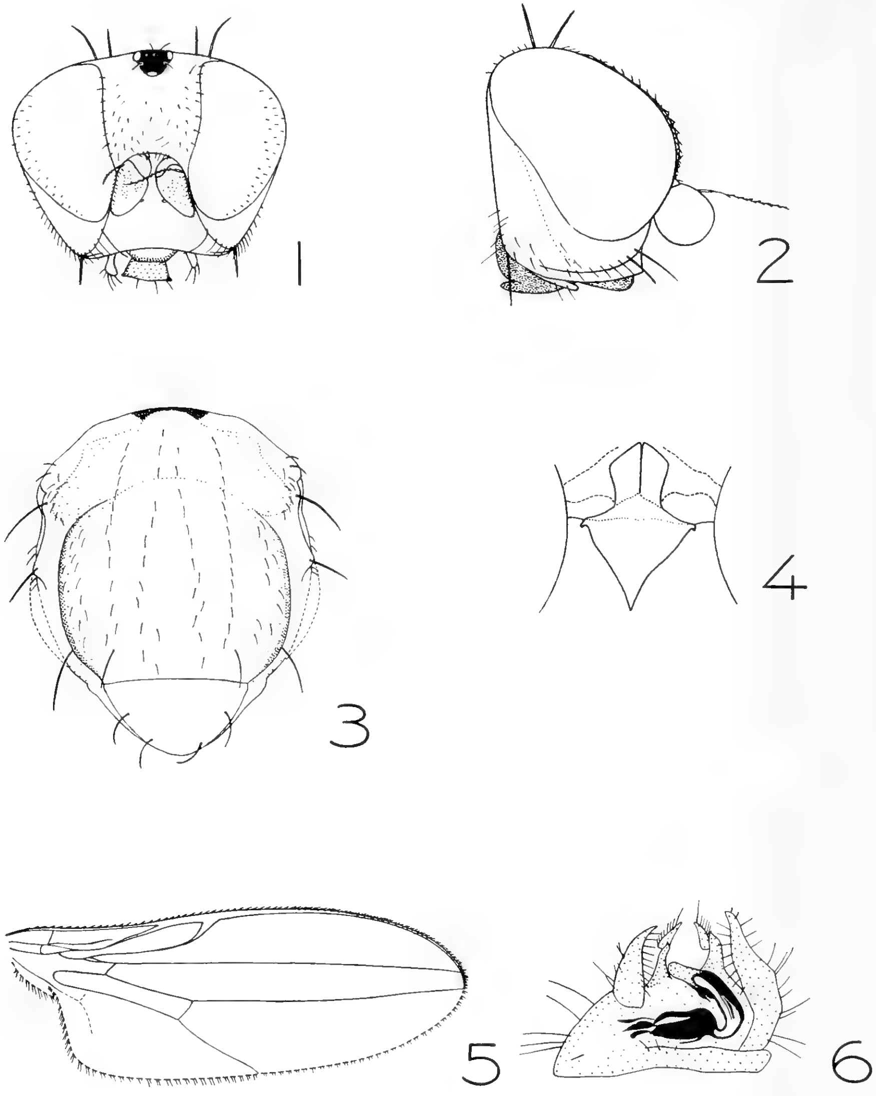
J. C. Deeming

Abstract.—Two new species of the genus *Phlebosotera*, *P. sabroskyi* and *P. inuwa*, are described from northern Nigeria.

The genus *Phlebosotera* was erected by Duda (1927:125) to accommodate his new species *mollis* from Cyprus. Sabrosky (1956:234) modified the generic diagnosis and (1956:235) gave a key to the Old World species, which included four Palaearctic and two Ethiopian species. Frey (1958:48) described a further species from the Canary Islands. A further three species are known from the Nearctic (Sabrosky, 1943:511 and 1957:50–51) and one from the West Indies (Sabrosky, 1957:51). Two new species are here described from Nigeria. Both species, like the type-species, have the male postabdomen asymmetrical and the aedeagus very large, heavily sclerotized and of a complicated structure.

Phlebosotera sabroskyi Deeming, new species
(Fig. 1–6)

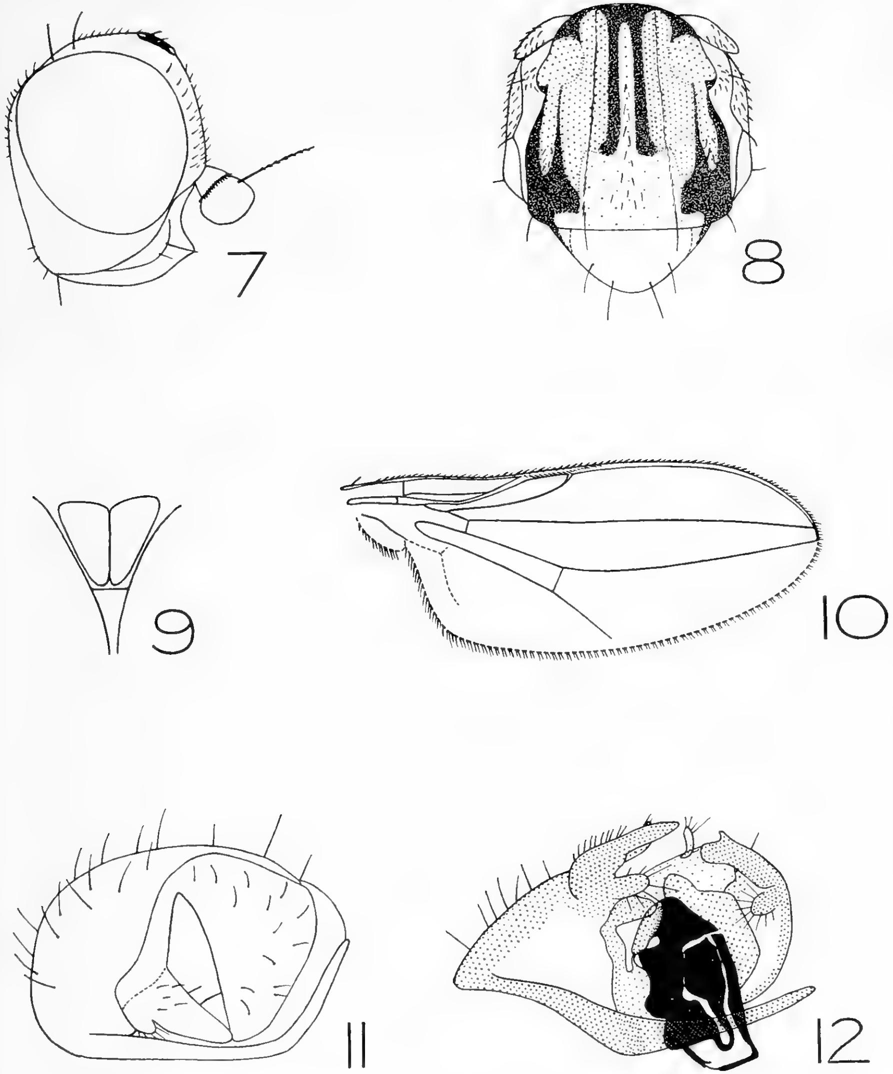
Male.—Head yellow with all hairs and bristles yellow; frons rather brownish tinged, in profile (Fig. 2) hardly raised above eye, with slightly sunken, subshining but ill-defined greyish-white stripe extending forwards from internal vertical bristle almost to level of anterior ocellus and slightly raised area bearing ocelli matt black; facialia and jowls slightly infuscate, but ground color obscured by coarse whitish-grey dust; pair of minute infuscate porelike spots present on face at slightly above ½ its height; occiput greyish dusted; eye with short pale hairs; antenna yellow with part of inner surface of 3rd segment brownish and arista black; palpus yellow with hairs of moderate length; proboscis brown. Thorax yellow, coarsely grey dusted dorsally, more weakly dusted laterally and ventrally; mesopleuron with long shining brownish-black mark along its lower border; postnotum brownish black; bristles and hairs of mesonotum and scutellum dark brown, single sternopleural bristle and fine hairs on mesopleuron and sternopleuron yellow; prosternum (Fig. 4) joined to mesosternum and linked to widely-separated fore coxae by membranous bridge. Wing (Fig. 5) yellowish hyaline with yellow veins; haltere yellow. Legs yellow, weakly yellowish dusted and with yellow hairs. Abdomen yellow, basally appearing a little darker, weakly sclerotized and weakly yellowish dusted, tergites bearing short brown hairs; terminalia (Fig. 6). Length about 1.75 mm, of wing 1.90 mm.



Figs. 1–6. *Phlebosotera sabroskyi,* male; 1. Head from in front; 2. Head in profile; 3. Thorax from above; 4. Prosternum, mesosternum and inner margin of fore coxae; 5. Wing; 6. Terminalia from beneath.

Female.—Unknown.

Holotype.—♂, N. NIGERIA: Katsina, 24.v.1975, (J. C. Deeming), on *Ficus* foliage. Deposited in USNM No. 73939. This species is closely related to *P. cyclops* Sabrosky 1956:236, but differs from it in the following respects:



Figs. 7–12. *Phlebosotera inuwa*, male; 7. Head in profile; 8. Thorax from above; 9. Prosternum and inner margin of fore coxae; 10. Wing; 11. Terminalia from behind; 12. Terminalia from beneath.

Only a single dark pleural spot; vertical bristles greyish white, unlike the more or less infuscate mesonotal bristles; distance between posterior ocelli slightly less than that between posterior ocellus and eye margin; frons between internal vertical bristles slightly less than the width of an eye; the rows of acrostical hairs, though irregular, becoming further apart postsuturally, on the posterior ⅓ of mesonotum more widely separated from each other than from the dorsocentral lines; wing with 2nd vein very greatly dilated apically and 4th vein straighter, the 1st posterior cell at its widest point less than 3× its width at wing tip.

Phlebosotera inuwa Deeming, new species
(Fig. 7–12)

Male.—Head ivory white, very weakly dusted; a large U-shaped brown mark on occiput extending from neck to base of internal vertical bristle on either side, this connected above to pair of rugose yellow bands that fill frons on either side of ocellar triangle and extend forwards, becoming progressively narrower, tapering to points ¾ of the way from anterior ocellus to anterior margin of frons; ocellar prominence matt black; vertical bristles, minute ocellars and double row of minute hairs behind ocellar prominence black, minute hairs clothing frons brown and vibrissa and jowlar bristles yellow; eye very sparsely, short pale haired; antenna yellow with arista and hairs ringing 2nd antennal segment black; palpus yellow, apically with long yellowish-brown bristle about ½ as long as palpus; proboscis yellow with yellow hairs. Thorax yellowish white, subshining through very weak yellowish dust and (Fig. 8) with brown and yellowish-brown markings on mesonotum, postnotum brown and faint indication of brown spot in front of base of single pale sternopleural bristle, mesonotal and scutellar bristles black and pleural hairs yellow; prosternum (Fig. 9) separate from mesosternum and only narrowly separated from the fore coxae. Wing. (Fig. 10) yellowish hyaline with yellow veins; haltere yellow. Legs yellow with yellow hairs, apical 3 segments of fore tarsus infuscate. Abdomen yellow, subshining, weakly sclerotized and bearing numerous brown to yellowish-brown hairs; terminalia (Figs. 11–12) large. Length about 1.6 mm, of wing 2.0 mm.

Female.—Unknown.

Holotype.—♂, N. NIGERIA: Zaria, Samaru, 9.iii.1973, (J. C. Deeming). Deposited in USNM No. 73938.

Paratype.—♂, N. NIGERIA: Katsina Prov., Maska Fish Farm, 26.iii.1972, (J. C. Deeming). Paratype deposited in the Inst. Agric. Res., Samaru.

Etymology.—The specific name is taken from the Hausa word for shade or shadow, as both specimens were collected hovering in the shade of large trees (mango and *Parkia*) on days of exceptional heat.

Discussion.—This species is probably more closely related to *P. nigriseta* Sabrosky (1956:237) than to any other described species, but it differs from *P. nigriseta* in lacking large black spots on the meso-, sterno-, and hypopleura and small spots in front of and behind the anterior (mesothoracic) spiracle, and in having the sternopleural bristle pale and the tergites yellow.

Acknowledgments

My thanks are due to Mr. J. P. Dear of the British Museum (Natural History) for allowing me to dissect the male that was tentatively identified by Sabrosky (1956:236) as *P. mollis* Duda and to the Director, Institute for Agricultural Research, Samaru for the facilities for research.

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Institute for Agricultural Research, Samaru, P.M.B. 1044 Zaria, Nigeria.

NOTE

A CASE OF HOMONYMY IN THE GENUS *MACHIMUS* (DIPTERA: ASILIDAE)

Oldroyd described *Machimus truncatus* (1972. Pac. Insects. 14(2):289–290) as a new species based on specimens collected on the island of Luzon in the Philippines. Subsequently, Martin described a new species of *Machimus*, which he also named *truncatus* (1975. Occ. Pap. Calif. Acad. Sci. No. 119: 41–42) from Cuernavaca, Mexico. Based on the published descriptions, it is apparent that two different species are involved. Consequently, according to Article 53 of the International Code of Zoological Nomenclature (1961), the junior primary homonym, *M. truncatus* Martin, must be rejected and replaced. Therefore, I propose that the name *Machimus truncatus* Martin be replaced by the name *Machimus lurettae* Martin in honor of the late Dr. Charles Martin's second wife, Luretta Martin, who assisted him greatly in preparing his later papers for publication.

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Robert J. Lavigne, *Entomology Section, Plant Science Division, Box 3354, Univ. Stn., University of Wyoming, Laramie, Wyoming 82071.*

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THE VELIIDAE (HETEROPTERA) OF AMERICA NORTH OF MEXICO—KEYS AND CHECK LIST

Cecil L. Smith and John T. Polhemus

Abstract.—Keys, supplemented with scanning electron micrographs and drawings, are presented for the five genera and 35 species of Veliidae of North America north of Mexico. Distributions and synonymies are given in a check list. A selected bibliography pertaining to these taxa is included.

Although the veliids are by far the most abundant of the surface-inhabiting Heteroptera and second only to the Gerridae in species diversity, they are usually ignored by the average collector and are poorly represented in most collections. This relative obscurity is due primarily to their small size (1–12 mm) and their penchant for living in cryptic habitats. Only the Rhagoveliinae are found on open stretches of water—*Rhagovelia* below the ripples and eddies of streams and *Trochopus* along shorelines of tropical bays and estuaries. The microveliine genus *Husseyella* shares the marine habitat with *Trochopus* and inhabits the margins of salt marshes and similar niches. In general, *Microvelia* are found on or near the margins of practically all still waters—ponds, lakes, temporary puddles, and the quieter portions of streams and rivers, where they secrete themselves among the debris, venturing out onto the open water rarely. Unlike the Rhagoveliinae, members of this genus are not totally restricted to the water surface and are commonly found running over nearby rocks and mud flats. Even though individuals of the veliine genus *Paravelia* (= *Velia* of authors) are the largest of the North American veliids, they are less often encountered because they do not usually inhabit the water surface, but are often found, instead, on emergent vegetation, and occasionally on vegetation some distance from water.

There are comparatively few veliid species in North America: Five genera with 35 included species. Of these, only the genus *Rhagovelia* has been adequately monographed (Bacon, 1956). The key to *Rhagovelia* presented here has been adapted, in part, from his paper.

The Western Hemisphere *Microvelia* were reviewed by Torre-Bueno (1924a) and later revised by McKinstry (1933, unpublished). Torre-Bueno's paper encompassed only 22 of the currently valid 81 New World species. In addition to Torre-Bueno's key several regional keys to *Microvelia* have since been published (Bobb, 1974; Froeschner, 1962; Herring, 1950; Usinger, 1956; Wilson, 1958). Usinger's 1956 key to the *Microvelia* of California was largely based on McKinstry's unpublished work. A check list compiled by

Drake and Hussey (1955) is the most recent synoptic work on the genus. Smith has a monographic revision of the North and Central American *Microvelia* in progress, but since it will be some time before the results are published, the key presented here will hopefully suffice as an identification aid in the interim. The subgenera *Microvelia* (*Microvelia*) and *M.* (*Kirkaldya*) are separated by the vertically oriented, leaf-like, dorsal arolium found only in the latter. This arolium is often difficult to see, so it is not used as a character in the key. Because no consistent characters have yet been found for successfully separating alate individuals of *Microvelia sensu lato* or females of the subgenus *Kirkaldya*, the key is based primarily on apterous specimens and males of *Kirkaldya* species. However, this should result in only minimal inconvenience because the majority of specimens within most populations are apterous and males are present. The elimination of winged forms from the key has necessitated the omission of one species, *M. marginata* Uhler. This species is known in the U.S. only from a single alate specimen from Key West, Florida. *M. marginata* is prevalent throughout the Caribbean area, and this single U.S. record is probably based on a hurricane transported specimen. A similar occurrence following a tropical storm has been verified by Herring (1958) for *M. cubana* (= *M. portoricensis sensu* Herring, not Drake). The latter species quite possibly has adapted to and become established in southern Florida based on several collection records subsequent to Herring's original observation.

Other than basic descriptive work and a few extremely localized regional keys, the genus *Paravelia* has, until recently, been ignored. Members of this New World genus were considered congeneric with the Old World genus *Velia* until Polhemus (1976) revised their status. Generic concepts, distributions, and synonymies were reviewed by Polhemus but no comprehensive keys exist for the genus.

Key to the Genera of Veliidae of America North of Mexico

1\. Middle tarsi deeply cleft, with leaflike claws and plumose hairs arising from base of cleft (Fig. 1). Rhagoveliinae 2

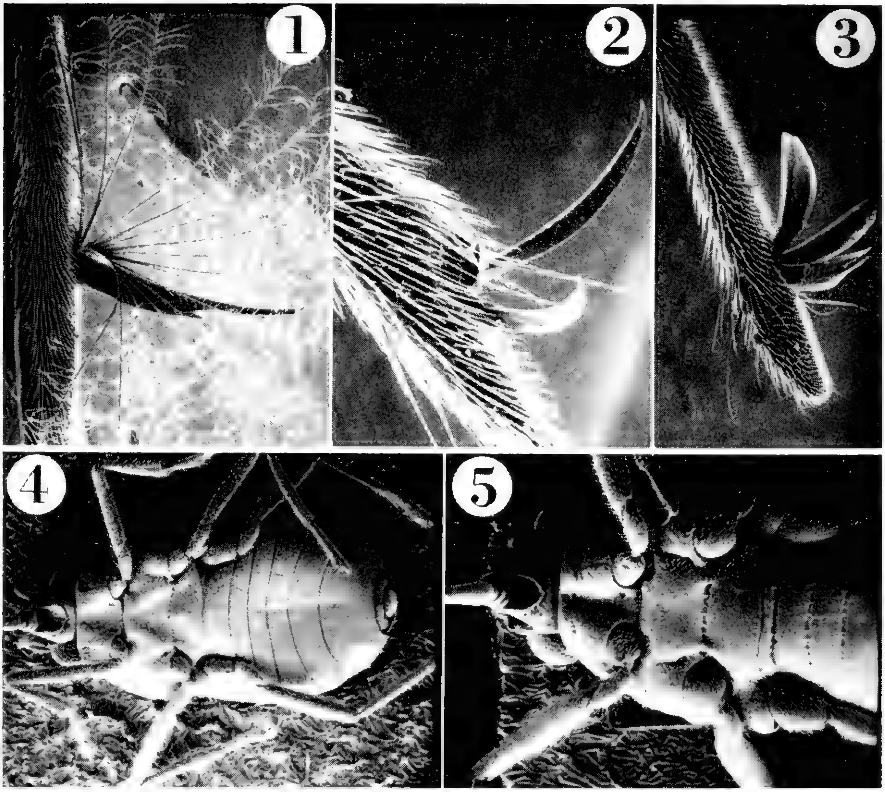
– Middle tarsi not deeply cleft and without plumose hairs arising from base of cleft 3

2\. Hind tarsi 2-segmented, the basal segment very short. Apterous. Tropical America. Marine *Trochopus* Carpenter
[One species, *T. plumbeus* (Uhler)]

– Hind tarsi 3-segmented, the basal segment very short. Apterous or macropterous. Cosmopolitan. Riffles of streams and rivers or (rarely) lakes *Rhagovelia* Mayr

3\. Tarsal formula 1:2:2. Microveliinae 4

– Tarsal formula 3:3:3. Veliinae *Paravelia* Breddin



Figs. 1–3. Tarsi. 1. *Rhagovelia obesa* (61×); 2. *Microvelia americana* (293×); 3. *Husseyella turmalis* (117×). Figs. 4–5. Ventral view of female *Microvelia* (31×). 4. *M. pulchella*; 5. *M. americana.*

4. Middle tarsi with 4 leaflike blades arising from cleft (Fig. 3) *Husseyella* Herring

[One species, *H. turmalis* (Drake and Harris)]

– Middle tarsi with narrow claws arising from cleft (Fig. 2) *Microvelia* Westwood

Key to Apterous *Microvelia* of America North of Mexico

[Except for species keyed in couplets 8 through 13, all species belong to the subgenus *Microvelia* (*Microvelia*).]

1. Pronotum covering entire thorax to metathoracic triangles, dorsal surface of thorax appearing 1-segmented (Fig. 6) 2

– Pronotum not covering entire thorax, at least 1 other thoracic segment exposed (Figs. 7, 8) 6

2. Minute, white, vestigial wing pads present; only 6 entire abdominal terga visible *atrata* Torre-Bueno

– Minute, white, vestigial wing pads absent; 7 entire abdominal terga visible 3

3. Blue to gray pruinose patches present on abdominal terga 2 and 3, and, usually, 6 and 7; orange-brown to dark reddish-brown species 4

– Blue to gray pruinose patches absent on all abdominal terga; color uniform sooty black (except orange transverse band across anterior lobe of pronotum) 5

4. Dorsum entirely covered with long erect pubescence, the majority of hairs equal in length to width of hind femur; 2nd genital segment of male without laterally directed caudal spines *fontinalis* Torre-Bueno

– Dorsum with only short pubescence, closely appressed to body; 2nd genital segment of male with a pair of short laterally projecting caudal spines *cerifera* McKinstry

5. Distal segment of middle tarsi 20% longer than proximal segment; coxae dark brown; females with glabrous depressed area on lateral margin of pronotum *glabrosulcata* Polhemus

– Distal segment of middle tarsi subequal to proximal segment; coxae yellowish; female lacking glabrous depressed area on lateral margin of pronotum *austrina* Torre-Bueno

6. Pronotum short; dorsal surface of thorax apparently consisting of 3 segments (Fig. 8) 7

– Pronotum longer; dorsal surface apparently 2-segmented (Fig. 7) 14

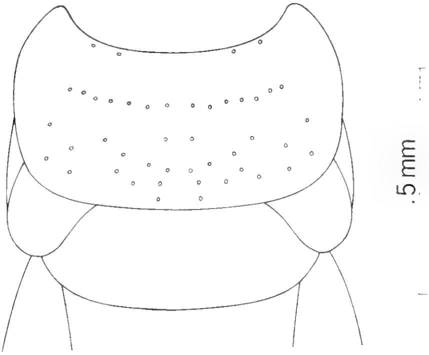
7. Hind tibiae of males curved; females with wide groove between front coxae for reception of rostrum, interior edges sloped gradually, divergent posteriorly (Fig. 4); front coxae widely separated; length normally less than 2 mm (1.25–2.25 mm) *pulchella* Westwood

– Hind tibiae of males straight; females with narrow groove, barely wider than rostrum, interior edges more vertical, parallel (Fig. 5); front coxae close together; length greater than 2 mm (2.00–3.75 mm) (subgenus *Kirkaldya*—key for males only) 8

8. Distal ventral margin of 1st genital segment glabrous or with only very short pubescence (Figs. 11–14) 9

– Distal ventral margin of 1st genital segment with either a row or tufts of long hairs (Figs. 15–19) (note that the tuft of hairs on *M. americana* may occasionally be shortened and, thereby, obscured) 10

9. Distal ventral margin of 1st genital segment with a triangular glabrous area (Fig. 11) *torquata* Champion



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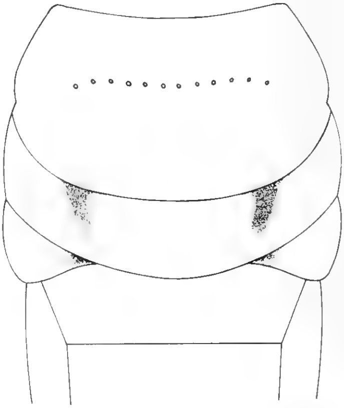

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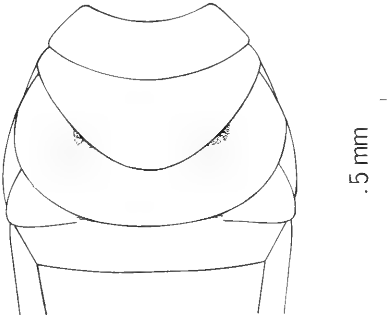

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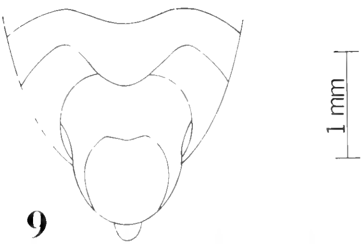

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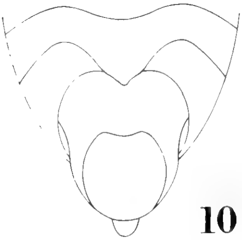

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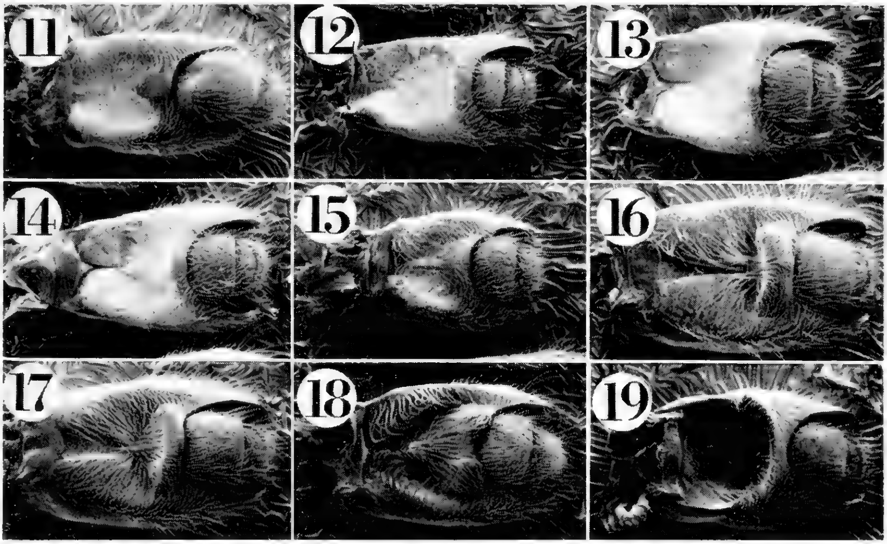
Figs. 6–8. Dorsal thoracic segments—*Microvelia*. 6. *M. fontinalis*; 7. *M. signata*; 8. *M. americana*. Figs. 9–10. Terminal ventral abdominal segments—*Paravelia*. 9. *P. summersi*; 10. *P. alvaradana*.

– Posterior ventral margin of 1st genital segment with only a narrow, transverse, glabrous area (Figs. 12–14) *paludicola* Champion

10\. Hairs on ventral surface of 1st genital segment arranged in 2 fairly distinct lateral tufts (Figs. 18, 19) 11



Figs. 11–19. *Microvelia* (*Kirkaldya*) male genital capsules (56×). 11. *M. torquata*; 12. *M. paludicola*—Miss.; *M. paludicola*—Ga.; 14. *M. paludicola*—Tex.; 15. *M. americana*; 16. *M. gerhardi*; 17. *M. californiensis*; 18. *M. beameri*; 19. *M. fasciculifera*.

– Hairs on ventral surface of 1st genital segment aligned in a continuous pattern (Figs. 15–17) 12

11\. Venter of last abdominal segment with a short erect tubercle *fasciculifera* McKinstry

– Venter of last abdominal segment without tubercle *beameri* McKinstry

12\. Distal ventral margin of 1st genital segment with a raised transverse ridge (Figs. 16, 17) 13

– Distal ventral margin of 1st genital segment without a raised transverse ridge (Fig. 15) *americana* (Uhler)

13\. Middle of front femora distinctly swollen and blackened; inner surface of front femora flattened *gerhardi* Hussey

– Middle of front femora not swollen and blackened; inner surface not flattened *californiensis* McKinstry

14\. Antennal segment IV subequal (90%+) to width of head through eyes; middle ⅓ of 2nd abdominal tergum with darkened area; males with large acute tubercle on 2nd abdominal sternum *albonotata* Champion

– Antennal segment IV not longer than 75% of width of head through eyes; 2nd abdominal tergum without darkened area; males without ventral tubercle 15

15\. Last 3 abdominal terga with broad shining areas, covering 25–90% of at least 1 segment 16

– Last 3 abdominal terga with at most a thin, shiny, medial line present on last 2 segments (width of line, at most, 10% of maximum width of segment) 17

16. Silvery pubescence present on head around eyes and base of antennae, and shoulders of pronotum *buenoi* Drake

– Silvery pubescence absent on head around eyes and base of antennae, and shoulders of pronotum *signata* Uhler

17. Tibia of mesothoracic leg subequal in length (90%+) to width of head through eyes *cubana* Drake

– Tibia of mesothoracic leg less than 75% as long as width of head through eyes *hinei* Drake

Key to *Parvelia* of America North of Mexico
(= *Velia* of American Authors)

1. Body slender; genital segments of both sexes acuminate; wing pads or wings basally brown, without white markings *stagnalis* (Burmeister)

– Body robust; genital segments button-like (♀) or forming a blunt angulate projection (♂) but not acuminate; wing pads or basal wing spot white, conspicuous 2

2. Collar projecting, angulate behind eyes; pronotum not set off from collar by conspicuous row of pits *beameri* (Hungerford)

– Collar not projecting, not angulate behind eyes; pronotum set off from collar by a more or less conspicuous row of pits 3

3. First antennal segment approximately 1.25× as long as width of head through eyes, and 1.5× as long as 2nd antennal segment (southeastern U.S.) *brachialis* (Stål)

– First antennal segment approximately 1.5× as long as width of head through eyes, and 2× as long as 2nd antennal segment (southwestern U.S.) 4

4. Ventral projection of 7th abdominal sternum blunt (Fig. 9) *summersi* (Drake)

– Ventral projection of 7th abdominal sternum acuminate (Fig. 10) *alvaradana* (Drake and Hottes)

Key to *Rhagovelia* of America North of Mexico

1. Genital segments in both sexes mucronate; female connexiva produced caudad from 7th tergum as long mucronate processes *becki* Drake and Harris

– Genital segments bluntly rounded or triangular but not mucronate; female connexiva not produced caudad as long mucronate processes 2

2. Female midfemur transversely constricted at middle; males with-

out median shining areas on dorsum of abdominal segments *choreutes* Hussey

– Female midfemur may be dorsoventrally flattened but not transversely constricted at middle; males with at least 7th (last) abdominal segment having median dorsal shining area 3

3\. Female midfemur dorsoventrally flattened; connexiva reflexed for the last 4 segments. Males with dorsal median shining areas on at least the last 3 abdominal segments; if shining areas are small, posterior femur is not greatly incrassate 5

– Female midfemur not flattened; abdomen tapering evenly to apex, connexiva not reflexed. Males with dorsal median shining areas on only abdominal segment 7; posterior femora greatly incrassate 4

4\. Venter of abdomen orange brown over at least last 3 segments, thickly dotted with minute black conical setae. Males with abdominal venter carinate over 1st 3 segments *varipes* Champion

– Venter of abdomen blackish grey over all but 7th segment, without evident minute black setae. Male abdominal venter not carinate *torreyana* Drake and Hussey

5\. Apterous female with apex of pronotum continued into a long, elevated process. Apterous male pronotum triangular, its apex extending over metanotum, mesonotum exposed at sides *oriander* Parshley

– Apterous female with pronotum not produced at apex. Pronotum of apterous male not extending over metanotum 6

6\. Connexiva of apterous female diverging over apex of last abdominal segment, apex of connexiva rounded as seen from side. Venter of last abdominal segment of male flattened medially with prominent hairy ridges at each side *distincta* Champion

– Connexiva of apterous female close together or meeting at apex; apex of connexiva forming at least a 90° angle as seen from side. Male venter not flattened and without hairy ridges on 7th segment 7

7\. Abdominal dorsum of apterous male with only traces of median shining areas on a few segments in addition to segment 7. Mesonotum of apterous female tumid *rivale* Torre-Bueno

– Abdominal dorsum of apterous male and dorsum of metanotum with broad median shining areas; posterior trochanter of male armed with several small teeth. Mesonotum of apterous female tumid only at sides or not tumid 8

8\. Connexival margins of apterous female with 1st 2 segments curved; exposed portion of mesonotum longer than exposed portion of metanotum *obesa* Uhler

– Connexival margins of apterous female with 1st 2 segments straight; exposed portion of mesonotum shorter than exposed portion of metanotum *knighti* Drake and Harris

Check List—Veliidae of America North of Mexico

Genus *Husseyella* Herring 1955

turmalis (Drake and Harris) 1933	Southern Florida, Mexico, Caribbean, Middle America

Genus *Microvelia* Westwood 1834

albonotata Champion 1898	Canada, U.S. east of Rocky Mts., Mexico to Peru, Caribbean
americana (Uhler) 1884	Eastern U.S., west to Nebraska and Texas
atrata Torre-Bueno 1916	Georgia and Florida, west to Louisiana
austrina Torre-Bueno 1924a *parallela* Blatchley 1925	Southeastern U.S., Mexico
beameri McKinstry 1937	Southwestern U.S., Northern Mexico, Jamaica
buenoi Drake 1920a	Northern half of U.S., California, Canada, Alaska, (Florida?)
californiensis McKinstry 1937	California, Oregon, Baja California
cerifera McKinstry 1937	Iowa, Kansas, Nebraska, Colorado, New Mexico, Utah, Arizona, Nevada, California
cubana Drake 1951a	Southern Florida, Cuba, Dominican Republic
fasciculifera McKinstry 1937	Texas, New Mexico, Arizona, Mexico
fontinalis Torre-Bueno 1916	U.S. east of Mississippi River
gerhardi Hussey 1924 *americana* Uhler 1895	Western U.S., Northern Mexico
glabrosulcata Polhemus 1974	Arizona, Mexico
hinei Drake 1920b	Canada to Argentina

marginata Uhler 1893 *pudoris* Drake and Harris 1936	Southern Florida, Caribbean, Mexico, Panama, Venezuela, Peru
paludicola Champion 1898 *alachuana* Hussey and Herring 1950	Southeastern U.S., Kentucky, Tennessee, Arkansas, Oklahoma, Kansas, Texas, New Mexico, Mexico, Middle America, Caribbean
pulchella Westwood 1834 *capitata* Guérin-Meneville 1857 *borealis* Torre-Bueno 1916 *incerta* Kirby 1890 *robusta* Uhler 1894	Canada to Argentina, Caribbean
signata Uhler 1894b *oreades* Drake and Harris 1928 *setipes* Champion 1898	Southwestern U.S., Mexico, Middle America
torquata Champion 1898	Southwestern U.S., Mexico, Middle America

Genus *Paravelia* Breddin 1898

alvaradana (Drake and Hottes) 1952	Northwestern Mexico (Arizona?)
beameri (Hungerford) 1929	Arizona
brachialis (Stål) 1860 *australis* (Torre-Bueno) 1916 *stagnalis* (Uhler) 1894 (*nec.* Burmeister)	Southeastern U.S., Oklahoma, Texas, Mexico, to (?) Argentina, Caribbean
stagnalis (Burmeister) 1835 *paulineae* (Wilson) 1953 *watsoni* (Drake) 1919	Eastern U.S., Cuba
summersi (Drake) 1951b	Arizona

Genus *Rhagovelia* Mayr 1865

becki Drake and Harris 1936	Texas, Nevada, Mexico
choreutes Hussey 1925	Southeastern U.S. to New Mexico, California
distincta Champion 1898 *excellentis* Drake and Harris 1927 *mexicana* Signoret 1877 (nomen nudum)	Western U.S., Mexico, Middle America

d. arizonensis Gould 1931	
d. cadyi Gould 1931	
d. harmonia Gould 1931	
d. modesta Gould 1931	
d. proxima Gould 1931	
d. valentina Gould 1931	
knighti Drake and Harris 1927	Arkansas, Missouri, Oklahoma
obesa Uhler 1871	Eastern U.S., Southeastern Canada
arctoa Torre-Bueno 1924b	
flavicincta Torre-Bueno 1924b	
oriander Parshley 1922	Midwestern U.S.
rivale Torre-Bueno 1924b	Colorado, Kansas, Iowa, Missouri, Oklahoma, Nebraska, Texas
torreyana Drake and Hussey 1957	Western Florida
varipes Champion 1898	Arizona, New Mexico, Mexico
beameri Gould 1931	

Genus *Trochopus* Carpenter 1898

plumbeus (Uhler) 1894a	Florida (Gulf and Atlantic Coasts), Caribbean, Atlantic coasts of Mexico, Middle America and Northern South America
marinus Carpenter 1898	

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(CLS) Department of Entomology, University of Georgia, Athens, Georgia 30602; and (JTP) 3115 S. York, Englewood, Colorado 80110.

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PARASITISM OF ADULT *TABANUS SUBSIMILIS SUBSIMILIS* BELLARDI (DIPTERA: TABANIDAE) BY A MILTOGRAMMINE SARCOPHAGID (DIPTERA: SARCOPHAGIDAE)

Patrick H. Thompson

Abstract.—Larvae of *Macronychia* sp. near *aurata* (Coquillett) were taken from adults of *Tabanus subsimilis subsimilis* Bellardi which were collected near College Station, Texas in 1976. Multiple infestations of this tabanid suggest specific host selection by sarcophagid females. This host-parasite association is apparently the first described instance of parasitism between Sarcophagidae and Tabanidae; it is a rarity between a dipteran species and an adult tabanid. Also, this account illuminates a previously unrecognized instance of such parasitism in the Miltogrammini, a tribe of cleptoparasites characteristically attacking the immobilized insect prey of wasps and bees. Rearing methods, development, and larval behavior are described, as are several additional observations of sarcophagid parasitism of Tabanidae.

Immature stages of Tabanidae have been infested by dipteran parasites representing four genera of Tachinidae and one of Bombyliidae. Goodwin (1968) summarized the literature relating to the initial reports and descriptions of these six species of parasites and added a seventh species to the list, which also parasitized the larval stage. More recently, Spratt and Wolf (1972) found tachinid larvae (*Bactromyiella* sp.) in adults.

The following account describes an unusual host-parasite association between a dipteran species and an adult tabanid; and, apparently, documents the first such association between Sarcophagidae and Tabanidae. In addition, this account elucidates a previously unrecognized host relationship of the genus *Macronychia* in North America and describes an unusual case of primary parasitism in the Miltogrammini, a tribe of Sarcophagidae characteristically cleptoparasitic upon the provisions in Hymenoptera nests. (The term primary, in this case, refers to that usage defined by Allen (1926), and quoted in the conclusions of this paper.) The species discussed here is *Macronychia* sp. near *aurata* (Coquillett) and is hereafter referred to as *Macronychia* sp.

During anatomical dissection of a series of *Tabanus sulcifrons* Macquart adults collected in 1975, a 1.5 mm first-instar larva of Sarcophagidae was discovered in each of two specimens. Both parasites were located within the abdominal cavity of the host near the terminal abdominal segments. These *T. sulcifrons* flies had been frozen the week before (17 July), at which time they were removed from a Gressitt Trap located in the Navasota River bottoms near College Station.

A second association of adult horse flies with sarcophagid larvae found several weeks later was more remote. During separation of a wet 2-day-old Gressitt Trap catch from this same locality, another first-instar larva representing a second species of this family, was found on the wing of a *Tabanus nigripes* Wiedemann female.

A third association provided adult specimens documenting this parasitism in the Tabanidae, when unexplained cyclorrhaphous larvae were observed in a glass beaker containing adults of *Tabanus subsimilis subsimilis* Bellardi and *T. mularis* Stone; these insects were being held for later treatment with insecticides. Seven larvae had emerged, then, through the ruptured venter of one of two dead *T. s. subsimilis* females, and an eighth larva remained in the abdominal cavity of that insect. On the same day, seven smaller larvae were observed in a second female of *T. s. subsimilis* in another beaker. These were together in a ball near the ruptured abdomen of the inverted, dead host.

Over the following seven weeks, five more lots of larvae were removed from more glass beakers and from one-pint cardboard ice cream containers holding *Tabanus* spp. females. Most of these containers of five adults included one or more specimens of *T. s. subsimilis.* In one of these last five lots of larvae, two specimens were removed from a third infested female of this species, this specimen also showing an emergence hole in the abdomen ventrally.

Methods

In the first rearing attempts, sarcophagids were implanted within females of several *Tabanus* spp., the larger of these, such as *T. sulcifrons* and *T. atratus* F., being most satisfactory for this purpose. After horse flies were dealated and pinned, sarcophagid larvae were implanted individually within the ruptured abdominal venter of their hosts; such infested specimens were maintained in 10-dr vials containing damp sand. In later rearings, field crickets were used as hosts because they were more easily collected and contained more tissues and fluids. The heads and legs of crickets were removed, and after larval implantation, the infested insects were stored in stacked 68-mm Syracuse watch glasses. Sarcophagid pupae were transferred to 5-dr vials containing ½ in. of damp sand which was topped with the same depth of fine wood shavings. After their emergence, teneral adults were held overnight before pinning. Larval specimens from early large lots of material were killed in KAAD and stored in 95% ethyl alcohol. However, Sanjean (1957) noted that Dietrich's Fluid, containing ½ of the usual amount of glacial acetic acid, was more satisfactory for this purpose.

Observations

Development.—Because *Macronychia* larvae were no less than 6 mm when first observed, the exact period of development is unknown; however, the development remaining required two to eight days, with a median of six days. More favorable observations showed that the pupal period, for thirteen specimens, required sixteen days (ten larvae) and fifteen or seventeen days (two and one, respectively); this sixteen-day period for *Macronychia* sp. was considerably longer than the nine to twelve days required by ten sarcophagine species reared in the laboratory at the same temperatures of 25°C ± 1 by Sanjean (1957).

Larval behavior.—Once the mouthparts of larvae were exposed to haemolymph exuding from the host, the maggots began to feed at once. In two cases, larvae attacked crickets through intact body areas and attempted to penetrate the host through intersegmental membranes. In another instance, one unusually large larva of the eight larvae found in the first lot voraciously attacked the intact cervical membrane beneath the head of a living *T. s. subsimilis.* Except for this one case of aggressive host attack, larval behavior was scavenger-like, the maggots feeding on the dead and putrefying bodies of the hosts until pupation.

Larvae usually fed with the anal plates exposed at the surface of the integument; exceptionally, one larva completely buried itself within the digestive tract of a decapitated cricket. Pupation occurred externally from the host, except in one case, when a puparium was located within the drying abdominal cavity of a female horse fly (the abdomen of the fly had previously been cut to introduce the larva).

Discussion

The parasite (excerpted from Allen (1926), Downes (1965), Evans and Eberhard (1970), and Krombein (1967)).—Miltogrammini includes 75 species of flies in North America, the larvae of which, with rare exception, feed on the insect provisions captured by wasps and bees. Certain anatomical specializations have been recognized in several genera of the tribe and these help explain much about the biology of the adults. The females of *Amobia* and *Senotainia* are equipped with enlarged eye facets, frontally, to facilitate trailing Hymenoptera which bear prospective hosts for the flies. Conversely, the females of other species, such as those of *Phrosinella*, are non-trailing and seek the burrows of their fossorial hosts. When finding those nests, they employ flattened foretarsi in implanting their progeny in nearby pits. The proboscis is short in *Phrosinella*, and in other genera the adults of which are not known from flowers; while in the *Senotainia* species known to visit flowers, the proboscis is long and slender.

In the female flies of the *Macronychia* species considered here, the frontal eye facets and foretarsi are unmodified and the proboscis is very short. Apparently, little host biology of the genera lacking such modifications is known. Except for several rearings of *Macronychia* spp. from nests of two sphecid wasp genera (Krombein, 1964; Parker and Bohart, 1966), the relationships of the two North American species of this genus are poorly known. Both forms are widespread throughout the continental United States. On the other hand, two European species have been associated with wasps and bees and geometrid Lepidoptera (Thompson, 1951).

The host.—Although *Tabanus subsimilis subsimilis* has been found breeding in the marginal and riparian habitats typical of many Tabanidae—irrigation ditches and stock ponds (Burger, 1974) and bottomland forests (Thompson et al., 1977)—in southeast Texas, this species breeds extensively in upland situations having mineral soils and no standing water (Thompson, 1975). These larval collections from upland sites helped to explain the larger numbers, and the dominance, of the *T. s. subsimils* populations observed in a later study comparing adjacent upland and lowland faunas (Thompson, 1977). Most significant for the survival of *Macronychia* sp., this horse fly is abundantly accessible as a host throughout much of Texas. Also, in deference to foraging parasites and predators, the pupae of this species commonly protrude in vertical position from the soil surface. Finally, to complete the picture of host ubiquitousness, it is common—often, very abundant—throughout much of the period from March through September.

The host-parasite association.—*Macronychia* sp. was a common facultative parasite feeding upon *Tabanus s. subsimilis* adults in the vicinity of the airport-sewage treatment plant near College Station, Texas from 28 May through 14 July 1976. Although the regularity of this association must be confirmed by additional observations in following years, several facts suggest that the relationship between larvipositing females and host tabanids was selective, not accidental. First, in two of the seven lots of parasites observed, host females suffered multiple infestations (seven and eight larvae each); in one of these cases, seven larvae of the same size, then in the process of drying out, were found together in a ball within the eviscerated host abdomen. Therefore, larvae of both lots were probably sibling individuals deposited together on, or very near, the host. Secondly, all larvae were found in lots; i.e., at least two to eight larvae were discovered together in containers of horse flies, most of which held only five adults. The probability of two infested flies in one container is low, especially if this *Macronychia* was predominantly parasitizing *Tabanus s. subsimilis.*

On the other hand, the role of many Miltogrammini as cleptoparasites of fossorial Hymenoptera—a role in which these Sarcophagidae rely upon their hymenopterous hosts to provide the kinds of hosts upon which their larvae subsist—increases the biotic potential of insects which already risk life only as facultative parasites. This role suggests that Tabanidae are only one of many taxa attacked by this species.

Conclusions

In his early monograph on the Miltogrammini of North America (1926), Allen noted:

> "So far as I am aware, it has not yet been conclusively demonstrated that any of these flies are the primary parasites of phytophagous insects in their native habitat. All the records investigated by the writer indicated that while the flies do breed in the bodies of such hosts, they display no interest in them until after they have become the prey of some wasp."

In the light of Allen's comment, the findings reported here on the biology of a species of *Macronychia* are unusual; and these findings provoke interest in a relationship which could prove illuminating to the biology of the Miltogrammini and to their potential in managing noxious populations of *Tabanus subsimilis subsimilis* and of other Tabanidae.

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Veterinary Toxicology and Entomology Research Laboratory, Agric. Res. Serv., USDA, College Station, Texas 77840.

NOTE

HOLOTYPE DEPOSITION OF *HENICOMYIA BICOLOR*

The holotype of *Henicomyia bicolor* Lyneborg [♂ specimen, number 1212, Brazil, Nova Teutonia, 27°11′S, 52°23′W, xi-1944, Fritz Plaumann] was mistakenly deposited in the United States National Museum of Natural History [*In* Lyneborg, L. 1972. A revision of the *Xestomyza*-group of Therevidae (Diptera). Ann. Natal Mus. 21(2):368]. The specimen was borrowed by me from the Canadian National Collection and subsequently loaned to Lyneborg for inclusion in his monograph on the *Xestomyza*-group of Therevidae. The holotype of *Henicomyia bicolor* Lyneborg has now been redeposited in the Canadian National Collection, Ottawa, Ontario, Canada.

Michael E. Irwin, *University of Illinois and Illinois Natural History Survey, Urbana, Illinois 61801.*

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AN EVOLUTIONARY AND GEOGRAPHICAL OVERVIEW OF REPAGULA (ABORTIVE EGGS) IN THE ASCALAPHIDAE (NEUROPTERA)

Charles S. Henry

Abstract.—Eggs and repagula (abortive eggs) were examined in seven previously unstudied species of Ascalaphidae from both the Old and New World. In those forms that possess repagula, the ratio of egg length to repagulum length is shown to be an unreliable taxonomic character. The absence of repagula in all Old World split-eyed taxa so far examined is interpreted as a secondary loss in a monophyletic assemblage of owlflies derived from a rather primitive New World ancestor—a view substantiated by ovariole number and larval morphology. New World ascalaphids show progressive specialization in repagulum form and function from primitive entire-eyed genera like *Byas* and *Ascaloptynx* to derived split-eyed ones like *Ululodes* and *Cordulecerus.* Entire-eyed *Episperches* and split-eyed *Colobopterus* are judged transitional.

The Reverend L. Guilding (1827) coined the term "repagula" to describe the small, glossy, rod-shaped bodies that accompany the egg masses of certain split-eyed (ascalaphine) Ascalaphidae. These structures encircle each egg-bearing twig like a fence immediately below the fertile eggs: appropriately, the meaning of the Latin word *repagulum* is "little barrier." Henry (1972) verified the protective function of repagula against insect predators in *Ululodes mexicana* (McLachlan), which possesses eggs with very thin shells.

McClendon (1902) demonstrated that the repagula of *Ululodes* are in fact highly modified abortive eggs that develop in their own specialized ovarioles. More recently, New (1971) determined that abortive eggs are also characteristic of entire-eyed (neuroptyngine) Ascalaphidae, but that in these latter forms the structural differences between infertile and fertile eggs are slight. Henry (1972) showed that the abortive eggs of at least one neuroptyngine, *Ascaloptynx furciger* (McLachlan), serve as food for the newly enclosed larvae and perhaps provide them with the nourishment necessary for group defense against ants and other predators. Repagula of *Ascaloptynx*, then, are not true barriers and in fact lack the repellant fluid coating found on the repagula of *Ululodes* (Henry, 1972). Other studies have shown that in the neuroptyngine genus *Byas* Rambur the repagula share a common morphology with those of *Ascaloptynx*, while ascalaphines such as *Cordulecerus* Rambur, *Colobopterus* Rambur, and *Ascalorphne* Banks, possess repagula very similar to those of *Ululodes* (New, 1971; Henry, In Press). Repagula of intermediate form are characteristic of the specialized neuroptyngine genus *Episperches* Gerstaecker (New, 1971).

All ascalaphid genera mentioned above are restricted to the New World, but both the split-eyed and entire-eyed owlfly subfamilies have nearly world wide distributions. Early European insect anatomists—e.g., Brauer (1854) and Dufour (1860)—neither discuss nor figure anything resembling modified ovarioles in *Ascalaphus macaronius* Scopoli or *A. meridionalis* Charpentier. Other works that describe the egg masses of Old World Ascalaphidae make no mention of egg attendants (Westwood, 1888; Ghosh, 1913; Fraser, 1957). The implication is that none of the Old World owlflies oviposits repagula, while members of both subfamilies in the other hemisphere do so.

The present study introduces data on egg and repagula production in several other species of Ascalaphidae, including *Helicomitus dicax* (McLachlan), *H. festivus* (McLachlan), *Suphalomitus malayanus javanensis* Weele, *Hybris subjacens* (Walker), *Ascalaphus libelluloides* Schäffer, *Cordulecerus alopecinus* Burmeister, and *Colobopterus* sp. near *trivialis* and *consors* Gerstaecker. In each case, the presence or absence of repagula is noted, based either upon dissection of gravid females or upon study of field-collected egg masses. Numbers of normal and modified ovarioles per ovary are given whenever possible, and measurements of the proportions of eggs and attendants are tabulated. These data are compared with those of previous authors. The possible biogeographical and phylogenetic significance of the results is then discussed.

Methods and Materials

Adult ascalaphids suitable for dissection were preserved in 75% EtOH and examined under a WILD™ M5 stereoscopic dissecting microscope fitted with 10× eyepieces. Eggs and other structures were figured and measured by means of a *camera lucida* attachment for this microscope.

Material for the study came from several sources. The adult specimens from Shanghai, Madagascar, Java, and Paraguay were part of an extensive alcoholic collection of poorly labeled insects deposited in the Museum of Comparative Zoology (Harvard University) by the late G. C. Crampton. Egg masses of *Ascalaphus libelluloides* were collected by my wife and myself in the vicinity of Penne, Tarn et Garonne, France, during the last half of July, 1974. Eggs and repagula of the Panamanian ascalaphid *Colobopterus* sp. A were obtained from a captive female by R. E. Silberglied and A. Aiello on 26 May 1976, on Barro Colorado Island, Canal Zone, Panama. The identities of all adults were determined from Weele's (1908) monograph, while larvae of *Ascalaphus libelluloides* were identified from the keys of Rousset (1973). Comparative data on *Ululodes mexicana* and *Ascaloptynx furciger* were drawn from material assembled for an earlier study (Henry, 1972).

Results

Results are summarized chiefly in Table 1. The Ascalaphinae species studied belong to four of the seven accepted tribes of the subfamily: Suhpalacsini (*Helicomitus* and *Suphalomitus*), Hybrisini (*Hybris*), Ascalaphini (*Ascalaphus*), and Ululodini (*Cordulecerus* and *Colobopterus*). The Old World tribes Proctarrelabrini, Acmonotini and Encyoposini are not represented. Females of Old World taxa all have ten egg producing ovarioles per ovary; no specimens contained abortive eggs. On the other hand, the two New World species possess repagula within specialized ovarioles and display marked differences between the proportions of the fertile eggs and those of the egg attendants. Eggs of *Cordulecerus alopecinus* were by far the largest in the ascalaphines studied, while the most spherical (broadest) were found in *Ascalaphus libelluloides*. Repagula of *Colobopterus* sp. A were proportionately much longer and thinner than those of *Cordulecerus*, being only fractionally shorter than the eggs themselves (ratio of egg length/repagulum length = 1.10). Egg size varied markedly among individuals in both species of *Helicomitus* and in *Hybris subjacens* but did not appear to be closely correlated with maternal dimensions except in *H. dicax* (Table 2).

It may be argued that the sizes of eggs and repagula obtained from dissected females are not comparable to those of the same structures when oviposited. To test this, eggs and attendants obtained by dissection were compared with those attached to twigs in *Ululodes mexicana*, an ululodine ascalaphine species from southern North America. The results (Table 3) indicate that sizes are insignificantly different in each of the two classes of data and that the pooling of data for both unlaid and oviposited eggs or repagula of Ascalaphidae is probably valid.

Table 4 compares the ratio of egg length to repagulum length in masses obtained from several different individuals of both *Cordulecerus alopecinus* and *Ululodes mexicana*, in order to test New's (1971) hypothesis that this ratio is a reliable taxonomic character separating the egg masses of closely related species of New World Ascalaphinae. The ratio was found to vary widely in *U. mexicana*, ranging from 1.65–2.19 in the five masses reliably measured. The ratios obtained from four *Cordulecerus alopecinus* dissections ranged from 1.73–1.99. The ovariolar number is seven in *Ululodes mexicana* and eight in *Cordulecerus alopecinus*; both species possess four additional repagula-bearing ovarioles in each ovary.

Discussion

The results strengthen the hypothesis that repagula production is limited to Ascalaphidae of the New World. Previously, it was suspected only that members of the Old World genus *Ascalaphus* lacked abortive eggs

Table 1. Comparisons of egg and repagulum dimensions and of ovariole numbers for eight species of Ascalaphidae. Measurements of eggs and repagula were obtained both by dissection of gravid females (preserved in alcohol) and by examination of oviposited masses.

	Taxon	Collecting site	Structure	No. of diff. indivs. or egg masses	No. of ovarioles	Sample size	Mean length ± SD (mm)	Mean breadth ± SD (mm)
	Neuroptynginae							
New World	*Ascaloptynx furciger* (McLachlan)	N. America (Arizona)	Eggs	5 masses	—	19	2.21 ± .120	1.26 ± .046
			Repagula	3 masses	—	17	1.33 ± .101	0.68 ± .084
	Ascalaphinae							
Old World	*Helicomitus dicax* (McLachlan)	S.E. Asia (Shanghai)	Eggs	3 ♀♀	10	18	1.57 ± .250	0.90 ± .180
			No Repagula					
	Helicomitus festivus (McLachlan)	Madagascar	Eggs	3 ♀♀	10	17	1.36 ± .270	0.76 ± .110
			No Repagula					
	Suphalomitus malayanus javanensis Weele	S.E. Asia (Java)	Eggs	1 ♀	—	6	1.70 ± .156	0.99 ± .115
			No Repagula					
	Hybris subjacens (Walker)	S.E. Asia (Java)	Eggs	2 ♀♀	10	17	1.41 ± .194	0.80 ± .074
			No Repagula					
	Ascalaphus libelluloides Schäffer	Europe (S. France)	Eggs	6 masses	—	29	1.61 ± .085	1.19 ± .051
			No Repagula					
New World	*Cordulecerus alopecinus* Burmeister	Paraguay	Eggs	4 ♀♀	8	26	2.28 ± .078	1.21 ± .073
			Repagula	4 ♀♀	4	38	1.23 ± .073	0.28 ± .017
	Colobopterus sp. A. near *trivialis* & *consors* Gerstaecker	Panama	Eggs	1 mass	—	10	1.52 ± .049	0.77 ± .015
			Repagula	1 mass	—	2	1.35 – 1.40	0.21 – 0.23

Table 2. Major morphological measurements of individual ascalaphid adults compared with the dimensions of eggs obtained from the same individuals by dissection. Adult measurements include the lengths of body, forewing, and antenna and the width of the head across the eyes.

	Adult measurements (mm)				Egg measurements (mm)		
	Body L	Forewing L	Antennal L	Head W	Mean length ± SD	Mean breadth ± SD	*N*
Helicomitus dicax							
A	22.0	27.0	18.5	5.5	1.48 ± .058	0.80 ± .036	7
AA	22.0	26.5	18.0	5.3	1.28 ± .027	0.73 ± .045	5
A-3	23.0	29.0	19.0	6.0	1.90 ± .043	1.14 ± .023	6
Helicomitus festivus							
B	27.0	28.0	23.0	5.7	1.25 – 1.30	0.80	2
BB	25.0	27.0	22.0	5.5	1.63 ± .075	0.85 ± .044	8
B-3	27.0	29.0	20.0	5.7	1.09 ± .075	0.65 ± .024	7
Hybris subjacens							
D	28.0	35.0	30.5	5.6	1.29 ± .141	0.75 ± .045	10
DD	29.0	33.0	30.0	5.6	1.59 ± .073	0.87 ± .033	7

and associated modified ovarioles. The present work extends this suspicion to representatives of the ascalaphine tribes Suhpalacsini and Hybrisini and confirms the absence of repagula in the major constituent and nominate genus of Ascalaphini. Unfortunately, nothing is known of repagula formation in Old World Neuroptynginae; however, Fraser (1922) does not mention attendants accompanying the fertile eggs of *Balanopteryx umbraticus* Fraser in Madagascar.

Repagula production in New World ascalaphine owlflies is best in-

Table 3. Dimensions of eggs and repagula obtained from five dissected females of *Ululodes mexicana* compared with those obtained from three oviposited egg masses of the same species.

	Structure	No. of diff. indivs. or egg masses	Sample size	Mean length ± SD (mm)	Mean breadth ± SD (mm)
From	Eggs	5 females	40	1.89 ± .159	0.94 ± .083
Dissected Females	Repagula	5 females	50	0.99 ± .176	0.22 ± .028
From Oviposited	Eggs	3 masses	14	1.90 ± .099	1.06 ± .049
Egg Massess	Repagula[A]	2 masses	15	0.93 ± .084	0.23 ± .024

[A] From masses preserved in alcohol; dried egg masses possess eggs of normal size but withered repagula.

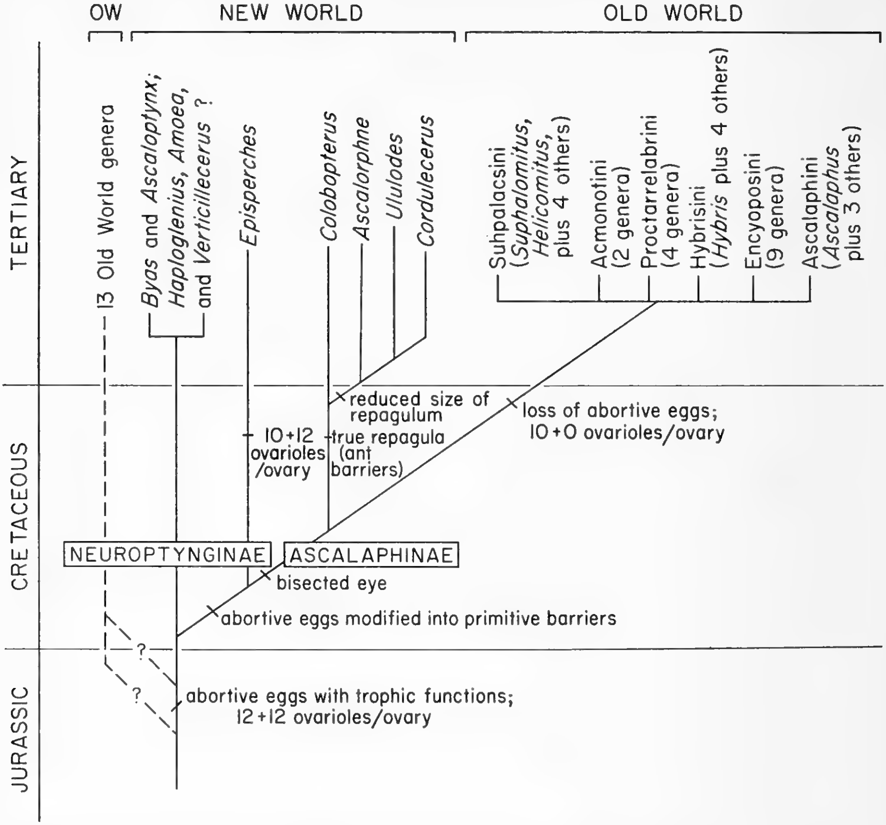

Fig. 1. Phylogeny of Ascalaphidae based upon structure of adult eyes, ovarioles, and repagula.

terpreted as a specialization within a monophyletic assemblage of insects (Fig. 1). All New World ascalaphids of the split-eyed subfamily are closely similar to one another in wing venation, abdominal terminalia, and antennal morphology and have been placed—in my view correctly—in a single tribe, the Ululodini (Weele, 1908). Similar types of fluid-covered repagula are found in representatives from every genus of the tribe. The effectiveness of the repagula against potential predators remains to be tested in taxa other than *Ululodes.*

New (1971) speculated that the repagulum of Ululodini is derived from one like that in the Neuroptynginae; the unavoidable implication from his paper is that the transition from a "simple" abortive egg like that of *Byas* to the specialized "rods" or "dumb-bells" of Ululodini occurred through some more specialized neuroptyngine genus (like *Episperches*) possessing repagula of intermediate morphology. Such views receive additional support from data given in Table 1 and in two previous papers (Henry, 1972 and In Press). However, the absence of any sort of abortive eggs in Old World ascalaphids is difficult to reconcile with a scheme that derives split-eyed owlflies from entire-eyed ancestors. Presumably, abortive egg production is a shared specialization of all Ascalaphidae, with further modification of abortive eggs into true repagula (predator barriers) occurring within certain Neuroptynginae that then gave rise to Ascalaphinae; this is the hypothesis borne out by data on New World forms. If this is true, one would expect to find egg attendants in some Old World taxa regardless of the evolutionary relationships among family members. For example, generalized Old World members of both subfamilies should possess unspecialized abortive eggs if one assumes that New World forms evolved from Old World ancestors that had already differentiated into two types with different eye morphology. Alternatively, the Old World ascalaphines, neuroptyngines, or both, might be derived from New World ancestors; in these cases, it is likely that split-eyed Old World taxa would retain and perfect some sort of specialized repagulum similar to that of Ululodini. Loss of repagula in derived taxa is possible, but the greater adaptive value to the eggs of attendants once the latter assume a protective function renders this hypothesis unattractive, as well. Unfortunately, too little is known of other aspects of ascalaphid morphology and biology to clarify the phylogenetic puzzle. However, larval morphology (Henry, 1976) and the orientation of eggs in naturally-occurring egg masses (Henry, 1972) suggest that New World Ascalaphinae are highly specialized in comparison with their Old World relatives; among other implications, this makes the secondary loss of egg attendants in the latter group seem even less likely.

If one assumes that repagula have not been lost secondarily, one must conclude that monophyly either of split eyes or of repagula production is an incorrect interpretation of ascalaphid evolution. Either aspect of this conclusion is difficult to accept. On the one hand, comparative morphology of the sulcate eyes of Old and New World Ascalaphinae indicates that the bisection is almost certainly homologous in representatives from the two hemispheres (Fig. 2). On the other hand, as far as is known, production of abortive or trophic eggs from modified ovarioles is unique to Ascalaphidae within the Neuroptera and very rare in other insect orders; the convergent evolution of such an apomorphy separately in Ascalaphinae and Neuroptynginae of the Western Hemisphere seems unlikely. What appears to be progressive increase in specialization of repagula from entire-eyed to split-eyed taxa in the New World is further evidence against convergent evolution of egg attendants in the two subfamilies; one may even interpret the *Colobopterus* repagulum as intermediate between that of *Episperches* and those of higher Ululodini (Fig. 3). Therefore, I feel

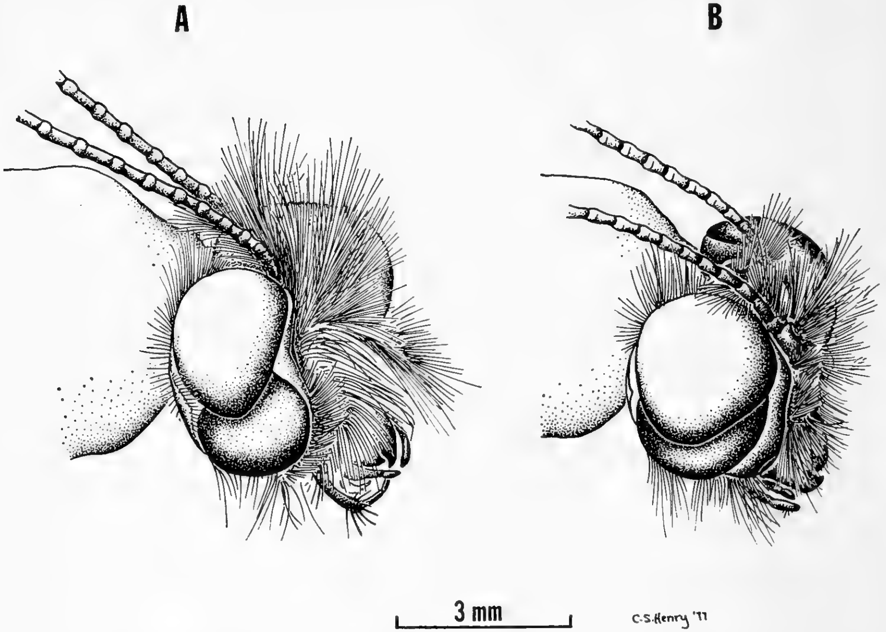

Fig. 2. Fronto-lateral view of the head of New World (A) and Old World (B) ascalaphine owlflies, showing bisected eyes. A = *Ululodes mexicana* and B = *Helicomitus dicax.*

that it is better at the present time reluctantly to postulate loss of repagula in Old World Ascalaphinae and to assume that all owlfly taxa in all geographical areas originated from New World neuroptyngine ancestors possessing primitive abortive eggs; bisection of the eye must also have developed first in the Western Hemisphere, with early colonization of the Old World by a primitive ascalaphine stock (Fig. 1). The position of African and Asian Neuroptynginae is uncertain in such a scheme since their eggs are so poorly known.

The presently uncertain systematic position of *Colobopterus* is rendered even more problematical by repagular morphology. Although it is widely accepted that *Ululodes quadrimaculata* (Say) is the female of *Colobopterus excisus* Hagen in North America, the *Colobopterus* sp. A near *trivialis* and *consors* discussed here is markedly divergent from any known species of *Ululodes* in the form and size of its egg attendants. Additionally, the larval morphology of another Panamanian species of the genus, *Colobopterus* sp. B near *mulleri* Weele, is totally unlike that of any known *Ululodes* (unpublished data). Consequently, it is probably valid to exclude some species of *Colobopterus* from *Ululodes*; in fact, the magnitude of repagular

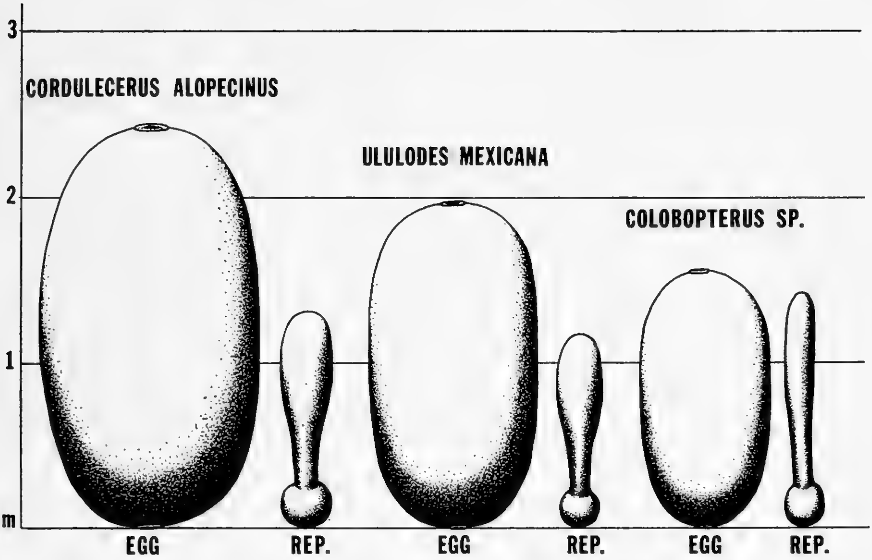

Fig. 3. The eggs and repagula of three New World owlflies of the tribe Ululodini, drawn to the same scale. REP. = repagulum.

and larval differences just mentioned suggests that some *Colobopterus* species are less closely related to *Ululodes* than is *Cordulecerus*, which possesses a *Ululodes*-like repagulum (Fig. 3).

Comparative measurements of eggs and repagula (Table 4) do not support New's (1971) contention that "the ratio of repagula [*sic*] length:egg length affords an index for separation of the egg masses of closely related species." In neither *U. mexicana* nor *Cordulecerus alopecinus* is such a ratio constant. At one extreme, the ratios for *Ululodes mexicana* are found to overlap extensively with those calculated from New's data for both *U. macleayana* near *limbata* Burmeister and *U. aurifera* McLachlan. At the other extreme, egg/repagulum ratios for New's *Cordulecerus alopecinus* are significantly different from my own measurements on the same species (1.37 vs. 1.88 ± .11, $N = 4$). Unfortunately, New gives neither means nor standard deviations of his data and does not make clear how many different egg masses his sample sizes represent.

The phylogenetic significance of ovariole number in Ascalaphidae has not been assessed. Within the Neuroptera as a whole, primitive taxa seem to exhibit larger numbers of ovarioles. For example, alderflies (Megaloptera: Sialidae) have up to 100 egg tubes per ovary (Matsuzaki and Ando, 1977), while green lacewings (Planipennia: Chrysopidae) possess only 12–15 (Hwang and Bickley, 1961; Rousset, 1976). New (1971) reported

Table 4. Comparisons of egg and repagulum lengths and of ovariole numbers for nine dissected individuals of *Ululodes mexicana* and four of *Cordulecerus alopecinus.* The ratio of egg length to repagulum length is calculated for each insect.

	No. of ovarioles/ ovary		Mean length ± SD (mm)		Ratio of egg length: repagulum length
	bearing eggs	bearing repagula	Eggs (*N*)	Repagula (*N*)	
Ululodes mexicana					
Skel.	–	–	1.95 ± .038 (5)	0.89 ± .053 (10)	2.19
DS-1	?	4	1.83 ± .087 (10)	1.04 ± .039 (7)	1.76
DS-2	?	4	1.70 ± .113 (9)	1.03 ± .063 (10)	1.65
DS-3	?	?	1.86 ± .095 (3)	0.72 ± .034 (13)	2.58
DS-4	7	4	immature		
DS-5	7	4	2.04 ± .073 (10)	1.17 ± .086 (11)	1.74
DS-6	7	4	2.02 ± .087 (8)	1.08 ± .036 (9)	1.87
DS-8	7	4	immature		
DS-9	7	4	immature		
Cordulecerus alopecinus					
E	–	–	2.29 ± .078 (8)	1.20 ± .032 (11)	1.99
EE	–	–	2.34 ± .046 (6)	1.24 ± .045 (8)	1.89
E-3	8	4	2.21 ± .047 (5)	1.16 ± .042 (9)	1.91
E-4	8	4	2.26 ± .083 (7)	1.31 ± .071 (10)	1.73

fairly high ovariole numbers of 22–24 in most of the owlflies he dissected, although repagula occupied twelve of the tubes. The neuroptyngine *Episperches arenosus* (Walker) showed a reduction from twelve to ten in the number of egg-producing ovarioles per side, while *Ululodes aurifera* of the Ascalaphinae exhibited only eight "fertile" and four "modified" tubes in each ovary. The present study confirms that these numbers need not be constant in a genus, since the ovary of *U. mexicana* has one less fertile ovariole than that of *aurifera* (Table 4)[1]. The discrepancy noted within *Cordulecerus alopecinus* between my own counts of ovarioles (8 + 4 per side) and those of New (12 + 12) indicates almost certainly that the two studies were not based on conspecific individuals. This might explain the differences obtained in egg/repagulum ratios, as well.

Old World ascalaphine forms examined here possess only ten ovarioles per ovary, as do members of the Eurasian genus *Ascalaphus* (Brauer, 1854; Dufour, 1860). Such a reduced ovariolar number is best interpreted as a specialization; the fact that it is shared by representatives of the tribes

Suhpalacsini, Hybrisini, and Ascalaphini from Europe, Asia and Africa strongly suggests close relationship among these taxa. The extant Old World Ascalaphinae, then, may indeed represent an adaptive radiation from the single primitive New World stock postulated earlier in the discussion. That this and all other evolutionary events within the Ascalaphidae took place after the separation of South America from Australia is strongly indicated by the total absence of Neuroptynginae from the latter continent; probably Africa and South America were in close proximity when owlflies with bisected eyes originated. Subsequent isolation of African Ascalaphinae by drifting of the continents in the Cretaceous produced the morphologically and behaviorally distinct Old World forms that we see today (Dietz and Holden, 1970). In the New World, repagula capable of repelling predators certainly arose subsequent to the establishment of a dominant ant fauna or "mosaic": at the earliest, within the Upper Cretaceous (Leston, 1973). This gives an independent approximate dating of certain later events of ascalaphid evolution synchronous with that derived from drift theory.

Acknowledgments

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Footnote

[1] An earlier study (Henry, 1972) reporting eight fertile egg tubes in *U. mexicana* is in error.

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LIFE HISTORY AND DESCRIPTIONS OF THE IMMATURE STAGES OF *JAMESOMYIA GEMINATA* (DIPTERA: TEPHRITIDAE)

W. Bryan Stoltzfus

Abstract.—The biology of *Jamesomyia geminata* (Loew) is discussed and the first-, second-, and third-instar larva and puparium are described and illustrated. Its seasonal distribution and relationship to its host plant *Lactuca canadensis* are included.

Jamesomyia was erected by Quisenberry (1949) for one species, *Jamesomyia geminata* (Loew). Quisenberry gave a genus and species description of *J. geminata* along with a record of its distribution.

The general life cycle is presented here, along with descriptions of the immature stages.

Life History

Females were found during July on the host plant (*Lactuca canadensis*) searching for flower buds of the proper size in which to oviposit. The female walked up and down the flower stalks, stopping intermittently to flex its wings. Elongate buds of about 5.5 mm were chosen for oviposition. The female inserted the ovipositor between the bracts at, or near the apex of the flower bud and laid a single egg among the florets.

Males are territorial and were found "patrolling" the upper leaves and flower buds of the host plant. As females came into the males' territory, the male exhibited courtship behavior, using stylized wing and body movements to attract the female. The male extended one wing slowly perpendicular to the body, then the other wing. Sometimes both wings were extended simultaneously. Quick side-ways body movements were also employed in attracting the female.

Larvae require about a month to be fully grown. They feed on the achenes, consuming all but an outer shell of the small number of achenes available (Fig. 7). The uneaten achenes and larval excrement are "glued" together to form a protective "puparium case" in which the mature third-instar larva overwinters. During August the host plant's seeds are dispersed and the puparium case falls to the ground. The mature larva usually pupates the following spring and adults begin emerging the last of June in northeastern Ohio.

Occasionally larvae pupated in August and adults emerged the same season. Whether adults of the second generation used the same species of plant as a host, or did not reproduce, was not determined.

The host plant, *Lactuca canadensis* L., occurred sparsely along old fence rows or the borders of a woods. *Jamesomyia geminata* was also infrequently found.

Of 100 heads of *Lactuca canadensis* examined, 38 contained larvae. Of these, 25% were parasitized by a wasp, *Habrocytus* sp. (Pteromalidae). An anthomyiid fly infested the same flower buds and seemed to be as common as *Jamesomyia geminata.* Occasionally the two species of larvae were found infesting the same head. If there is insufficient food for both larvae, the anthomyiid usually wins the competition. Frequently one of the two species was parasitized by a wasp but never both species.

Descriptions of Immature Stages

Third-instar larva.—Length 2.6–3.1 mm, width 1.4–2.2 mm (Fig. 1). White to light yellow as early third-instar larva, to nearly black, especially 1st and last segments of overwintering larva. Mature larva barrel-shaped, head and 8th abdominal segments dark brown, middle segments yellowish brown. Integument shagreened; no spinule patches on venter. Two irregular rows of strong spinules on dorsum of 6th and 7th abdominal segments, smaller spinules on other segments. Eighteen sensilla distributed around each segment. Pseudocephalic segment invaginated into the thorax. Overwintering larva with scalloped posterior border around 8th abdominal segment, posterior part being greatly darkened.

Anterior spiracles (Fig. 2) fan-shaped, with tubules, dorsal and ventral lobes branched, yellow to light orange. Stigmatic chamber distinctly divided into several cells, 3 across; about 5 lengthwise.

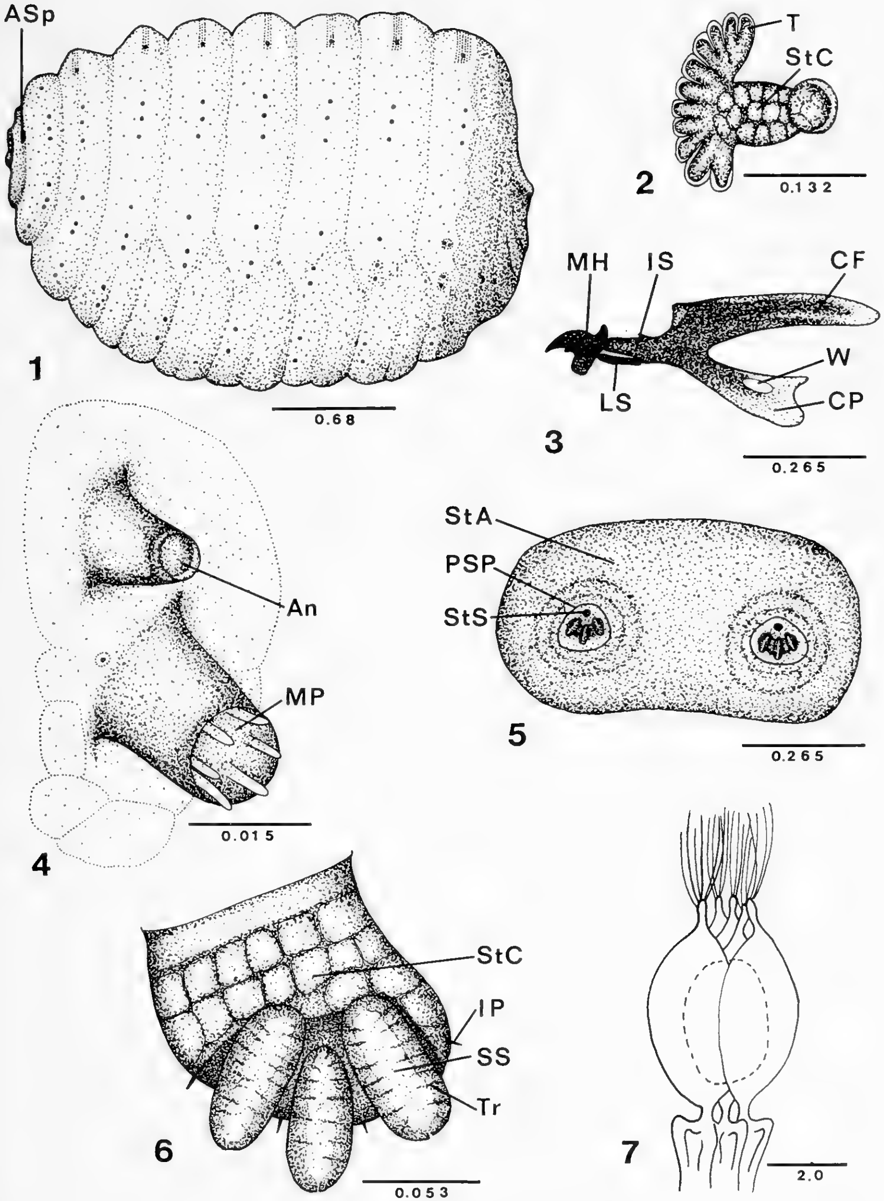
Cephalopharyngeal skeleton (Fig. 3) heavily sclerotized, bearing 1 accessory tooth midway on ventral margin of mouth hooks. Mouth hooks, 0.15 mm long, slightly longer than wide. Intermediate sclerite slightly longer than mouth hooks. Labial sclerite long and narrow. Cibarial phragma dark except distal portion which bears window.

Maxillary palp (Fig. 4) slightly longer than wide, bearing perhaps 5 or 6 short peglike segments distally. Antenna slightly longer and more conical.

Posterior stigmatic disc (Figs. 5, 6) smooth, bearing no lobes or ridges. Posterior stigmatic area dark, slits and stigmatic scar set off by much lighter stigmatic plate. Slits oval with bars extending inward ⅓ of way from each side, peritremes dark with very small opening at distal end. Slits about 0.056 mm long. Stigmatic chamber distinctly divided into 6 or 7 cells across and

→

Figs. 1–7. *Jamesomyia geminata* mature third-instar larva and plant infestation. 1. Larva; ASp, anterior spiracle; 2. Anterior spiracle; StC, stigmatic chamber; T, tubule; 3. Cephalopharyngeal skeleton; CF, clypeofrontal phragma; CP, cibarial phragma;



IS, intermediate sclerite; LS, labial sclerite; MH, mouth hook; W, window; 4. Antenna, An; maxillary palp, MP; 5. Posterior spiracular disc; PSP, posterior spiracular plate; StA, stigmatic area; StS, stigmatic scar; 6. Posterior spiracular plate; IP, interspiracular process; SS, stigmatic slit; StC, stigmatic chamber; Tr, trabeculae; 7. Pupation site among achenes of *Lactuca canadensis*.

3 or 4 deep. Interspiracular processes composed of 4 very small, short spikes, 1 on each side of a slit. Anal plate pale yellow, not shagreened and bearing no tubercles. Anal plate set off ventrally by shagreened area and dorsolaterally on each side by 2 papillae.

Second-instar larva.—Length 1.32–2.38 mm; width 0.61–1.32 mm. White to pale yellow, anterior end pointed, posterior end rounded. Integument not shagreened but spinules present as in third instar except no strong spinules on 6th and 7th abdominal segments. Anterior spiracles lighter in color and bear the same number of tubules as in third instar.

Posterior spiracular disc light yellow. Slits about 0.024 mm long.

Cephalopharyngeal skeleton dark except for lighter area at point of mouth hooks and distal ends of clypeofrontal and cibarial phragmata. Mouth hooks (about 0.1 mm) slightly longer than intermediate sclerite. No window in cibarial phragma.

First-instar larva.—Length 0.8–1.5 mm; width 0.4–0.61 mm. Mouth hooks and intermediate sclerite light brown, clypeofrontal phragma large and dark, cibarial phragma lighter and smaller. No labial sclerites; labial sclerite fused to intermediate sclerite. Mouth hooks about 0.018 mm long. No anterior spiracles. Two barely visible oval slits, which are only slightly pigmented, represent the posterior spiracles.

Egg.—Length 1.18–1.27 mm; width 0.24–0.27 mm. Dull white, micropylar end lanceolate, opposite end more rounded. No noticeable reticulation or other markings.

Puparium.—Length 3.45 mm; width 1.86 mm. Barrel-shaped, ends truncate as in third-instar larva. Puparium very thin and dark; black at ends; center dark brown. Anterior spiracles slightly raised; tubules as in third-instar larva. Posterior spiracular plates only very slightly raised. Spinules, when visible, as in third-instar larva.

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A NEW EGG PARASITE (HYMENOPTERA: SCELIONIDAE) OF THE ELM SPANWORM, *ENNOMOS SUBSIGNARIUS* (LEPIDOPTERA: GEOMETRIDAE)

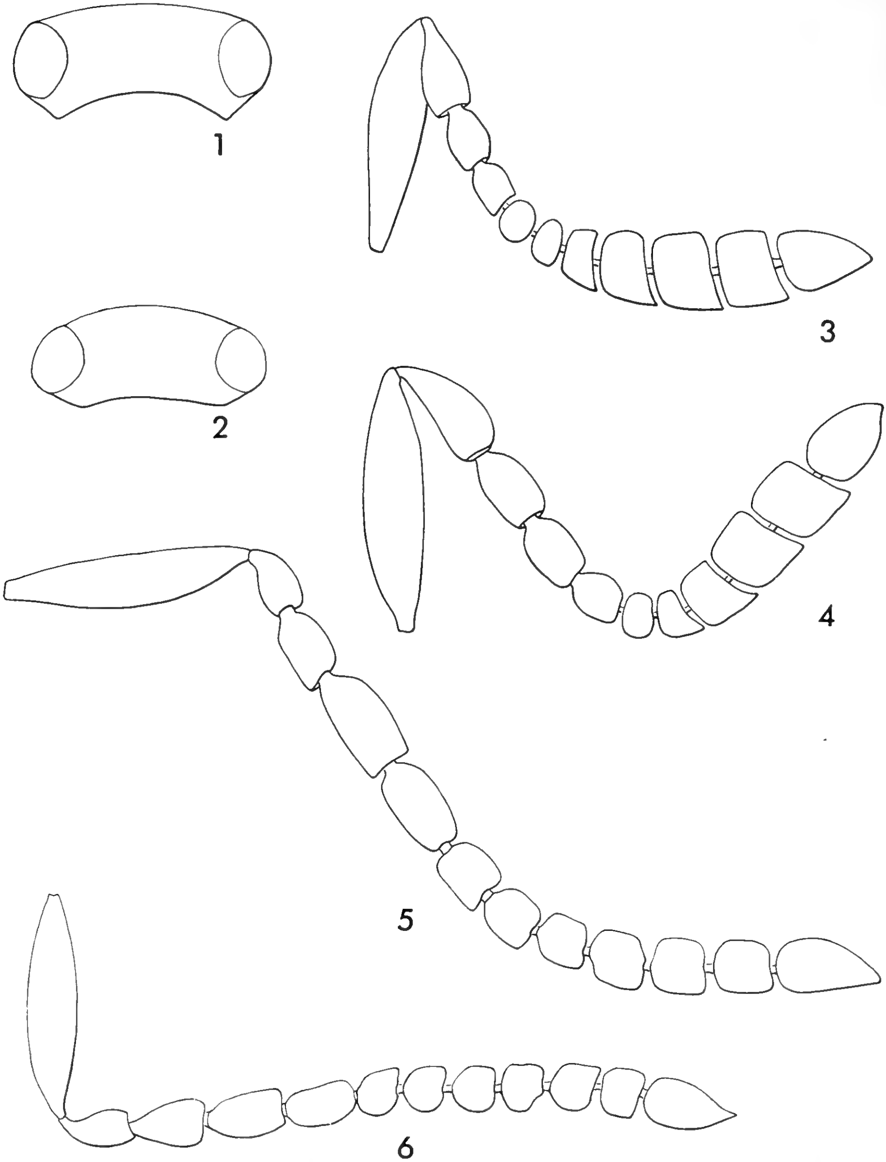
Carl F. W. Muesebeck

Abstract.—Telenomus droozi, new species, a parasite in the eggs of the elm spanworm, *Ennomos subsignarius* (Huebner), is described from Pennsylvania.

The species described below, which develops as a parasite in the embryonated eggs of the elm spanworm, *Ennomos subsignarius* (Huebner), has been confused with another parasite of geometrid eggs, *Telenomus alsophilae* Viereck. Recent studies (Drooz et al., 1976) have shown that it is distinct biologically and is not a parasite of eggs of the fall cankerworm, *Alsophila pometaria* (Harris), the normal host of *Telenomus alsophilae*. As a result of that disclosure, critical studies were made of both forms, and some morphological differences were discovered. Although these differences are subtle and sometimes not readily recognized, they appear to distinguish the two species.

Telenomus droozi Muesebeck, new species

This species may usually be distinguished without much difficulty from specimens of *T. alsophilae* that have developed in eggs of the fall cankerworm. It is consistently a little larger; the head is slightly narrower relative to the width of the thorax, and as seen from above it is a little flatter in front (Fig. 1); normally there is a continuous, narrow strip of delicate microsculpture along the inner eye margin (in *alsophilae* the frons medially is completely smooth and polished); there are slight but recognizable differences in the basal segments of the antennal flagellum (Figs. 4 and 5); and when the insect is viewed from the side, the level of the dorsum of the abdomen normally appears to be nearly on a line with that of the mesonotum whereas in *alsophilae* it is usually much lower. A. T. Drooz and certain of his associates at the Southeastern Forest Experiment Station, U.S. Department of Agriculture Forest Service, have found that *T. alsophilae* will develop in the eggs of a number of Geometridae other than *Alsophila pometaria*. When the eggs of the host species are larger (as in the case of *Abbotana clementaria* (J. E. Smith) and *Oxydia trychiata* (Guenée)), the resulting parasites are noticeably larger than those emerging from eggs of *Alsophila*; they are as large as specimens of *Telenomus droozi* and the antennae very closely resemble those of that species. However, the other differences mentioned above are apparent in these larger specimens also.



Figs. 1, 4, 5. *Telenomus droozi.* 1. Dorsal view of head; 4. Female antenna; 5. Male antenna. Figs. 2, 3, 6. *Telonomus alsophilae.* 2. Dorsal view of head; 3. Female antenna; 6. Male antenna.

No significant differences in the male genitalia of the two species have been noted.

Female.—Length approximately 1 mm. Head just about as wide as maximal width of thorax, in frontal view broadly subtriangular, in dorsal view as shown in Fig. 1; eyes weakly setose; surface of vertex with delicate reticulate sculpture; weaker microsculpture narrowly along inner eye margins; lower part of frons with delicate reticulate sculpture like that of vertex; elsewhere the frons smooth and polished; sharp margin bordering the eyes behind not continued as a ridge across vertex, which is rather smoothly convex from front to back; lateral ocelli situated on vertex at eye margins and barely above level of median ocellus; antenna as illustrated (Fig. 4).

Thorax with mesoscutum sculptured like vertex; disc of scutellum strongly transverse, smooth and polished; metanotum short, usually smooth but sometimes with a little microsculpture across base; propodeum short, very shiny, and with a little indefinite sculpture, especially laterally; forewings overreaching abdomen by hardly ½ length of the latter; hindwings about 5× as long as their maximal width; stigmal vein nearly as long as width of hindwing and ½ as long as postmarginal vein, the terminal end of which is rather vague but is determined by the row of 10 or 11 evenly spaced bristles arising from it.

Abdomen a little longer than thorax, apical segments usually not retracted; in lateral view level of dorsum of abdomen nearly on a line with level of posterior part of mesonotum; 1st segment of gaster dorsally with a row of foveae or short striae across base; large 2nd segment smooth and polished but sometimes with a row of minute punctures across extreme base.

Coloration.—Black; antennae, including scapes, black; legs largely black or blackish, the tarsi usually paler; wings hyaline.

Male.—Essentially like the female except for the antennae (Fig. 5), a smaller abdomen and paler legs.

Holotype.—USNM No. 74012.

Described from 40 females (one, the holotype) and 41 males reared 2 June 1976, by A. T. Drooz from eggs of *Ennomos subsignarius* (Huebner) which had been collected at Pottersdale, Pennsylvania.

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Cooperating Scientist, Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

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NOTES ON THE SYSTEMATICS AND BIOLOGY OF THE BITING MIDGE, *FORCIPOMYIA ELEGANTULA* MALLOCH (DIPTERA: CERATOPOGONIDAE)

Willis W. Wirth and William L. Grogan, Jr.

Abstract.—The immature stages of *Forcipomyia* (*Forcipomyia*) *elegantula* Malloch are described and illustrated for the first time. Adults are redescribed and illustrated, and all stages are compared with the closely related European species *P. pulchrithorax* Edwards. Biological notes are given on this species which was found breeding under the bark of dead cottonwood trees on Plummers Island, Maryland. The structure and function of the peculiar hygroscopic hairs of the larva and their defensive value against predators are discussed.

We are indebted to Theodore J. Spilman for the discovery, during June 1976 on Plummers Island, Maryland, near Washington, D.C., of a large population of the biting midge *Forcipomyia* (*Forcipomyia*) *elegantula* Malloch. Large numbers of all stages of this strikingly marked midge were found under the thick bark on the trunks of large cottonwood trees (*Populus deltoides* Bartram) that had been felled by resident beavers and had lain on the river bank for a year or more. The colonies of the midge lived in the layers of tissue-thin inner bark next to the cabium where there was enough moisture to support a copious growth of microorganisms. A complex and rich biota of coleopterous and dipterous larvae and Collembola fed on these microorganisms or preyed on the herbivores. Fungal spores appeared to make up the bulk of the gut contents of the *Forcipomyia* larvae.

Malloch (1915) described *Forcipomyia elegantula* from adults collected at his laboratory window in Urbana, Illinois. Nothing has since been reported on this species. It is very similar to the Palearctic *F. pulchrithorax* Edwards (1924), described from specimens bred from wood debris and from sap flowing from wounds of elm and chestnut trees in England. Saunders (1924) described the immature stages of *F. pulchrithorax* and the species has since been reported from Hungary, Belgium, Germany, and Estonia. We take this opportunity to present for the first time descriptions and illustrations of the immature stages of *F. elegantula*, figures and redescriptions of the adults and comparisons of all stages with those of *F. pulchrithorax*.

We are especially indebted to Ethel L. Grogan for preparing the illustrations. We also extend thanks to M. E. Taylor for aid in preparing the scanning electron micrographs. The junior author carried on the field work on Plummers Island during the summer of 1976 with financial support from a research grant from the Washington Biologists' Field Club.

Forcipomyia (*Forcipomyia*) *elegantula* Malloch
(Figs. 1–4, 6, 12–20)

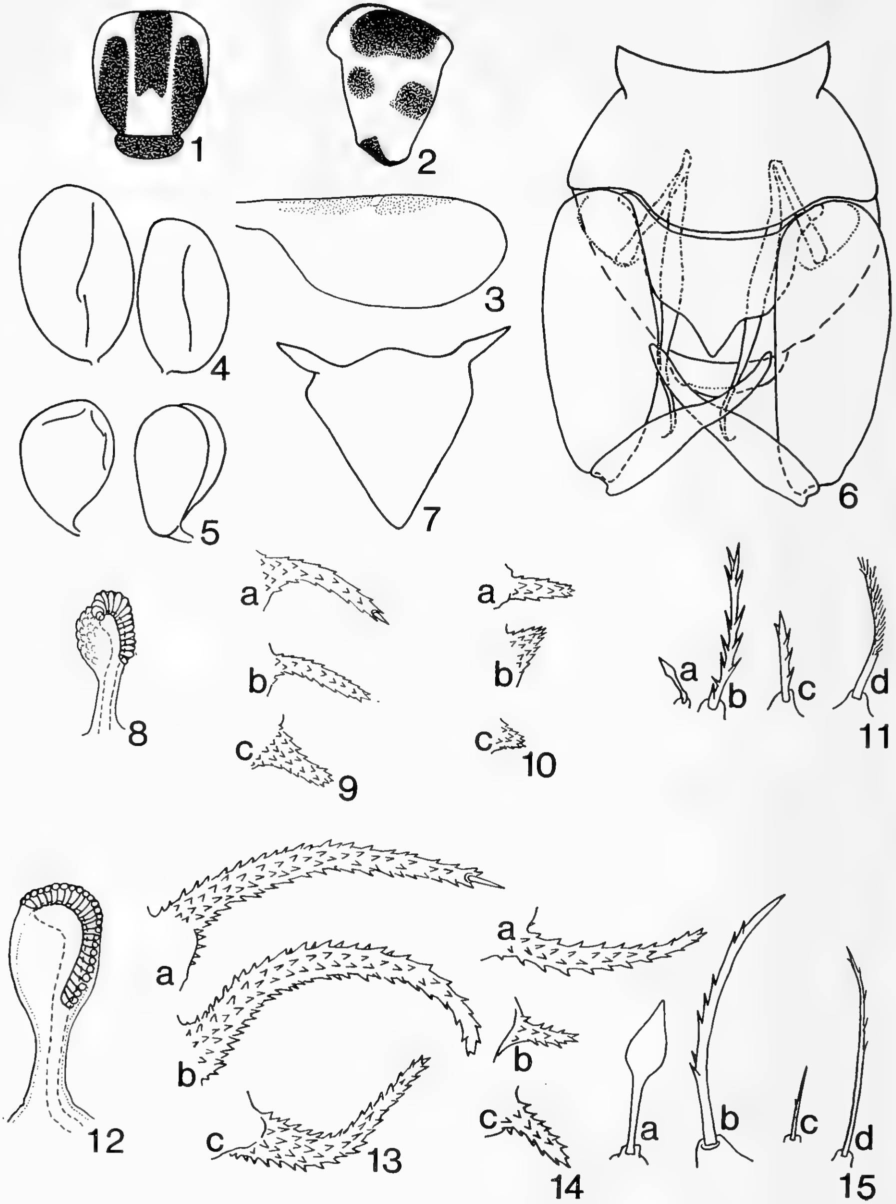
Forcipomyia elegantula Malloch, 1915:311 (male, female; Illinois); Johannsen, 1952:157 (in key to spp. NE USA).

Forcipomyia (*Forcipomyia*) *elegantula* Malloch; Johannsen, 1943:777 (in list N. Amer. spp.); Wirth, 1965:125 (USA distribution).

Diagnosis.—A large yellowish species most closely resembling the Palaearctic *F. pulchrithorax*; distinguished from all other Nearctic *Forcipomyia* (*Forcipomyia*) by the following combination of characters: Adults with 3 black stripes on scutum and 2–3 black spots on pleuron; hind femur with black band on distal ¼; tibiae of female with hastate setae. Females differ from *F. pulchrithorax* in having a black band on hind femur and oval rather than pyriform spermathecae; males differ from that species in having a shield-shaped aedeagus with a concave basal arch and pointed tip, the aedeagus of *F. pulchrithorax* being triangular with a convex basal arch. Pupa with respiratory horn with reticulate surface and 25–30 spiracular papillae, and much shorter thoracic and abdominal processes than in *F. pulchrithorax*. Larva with large hastate *a* hairs; *a* hairs smaller and only slightly hastate in *F. pulchrithorax*.

Female.—Wing length 1.45 mm; breadth 0.60 mm. Head: Frontoclypeus, scape and pedicel of antenna yellow; vertex, flagellum of antenna, and palpus yellowish brown. Proximal 8 flagellomeres globose, possessing multiple sensoria; distal 5 elongate, lacking sensoria; apical flagellomere with distinct apical papilla; flagellomeres with lengths in proportion of 18-14-15-15-15-15-15-15-21-21-21-22-29; antennal ratio 1.07. Palpus with segments in proportion of 11-13-32-17-11; 3rd segment expanded basally with distinct deep pit bearing numerous minute sensilla; palpal ratio 2.46. Mandible reduced. Thorax: Yellowish. Scutum (Fig. 1) with 3 black stripes, the median 1 bifid posteriorly; scutellum and postscutellum black; pleuron (Fig. 2) with 2–3 round black spots, black stripe on sternum. Legs yellow; hind femur with black band on distal ¼; tibiae with large hastate setae; femora and tibiae with long setae. Wing about 2.5× longer than broad, covered with dense macrotrichia; pattern (Fig. 3) with lightly infuscated area on and distad of costa; costal ratio 0.45. Halter stem pale, knob white. Abdomen: Yellowish; terga and last 3 sterna brown, giving abdomen a banded appearance. Spermathecae (Fig. 4) oval, subequal with very short necks.

Male.—Similar to female, differing as follows: Flagellar plume brown; tibiae lacking hastate setae; wing more slender. Genitalia: As in Fig. 6. Ninth sternum about 2× as broad as long; caudomedian margin convex; 9th tergum tapered distally, posterior margin rounded, cerci very reduced. Basistyle nearly straight, 2.5× longer than broad; dististyle curved slightly



Figs. 1–15. *Forcipomyia elegantula* (Figs. 1–4, 6, 12–15) and *F. pulchrithorax* (Figs. 5, 7–11). 1. Color pattern of scutum; 2. Color pattern of pleuron; 3. Color pattern of female wing; 4–5. Spermathecae; 6. Male genitalia; 7. Aedeagus; 8, 12. Pupal respiratory horn; 9, 13. Thoracic processes of pupa; 10, 14. Abdominal processes of pupa; 11, 15. Abdominal hairs *a*, *b*, *c*, *d* of larva.

distally, 0.67× length of basistyle, tip darkened and slightly pointed. Aedeagus lightly sclerotized, shield-shaped; basal arch concave; basal arm short with rounded, slightly recurved tip; distal portion with pointed tip. Claspettes divided, lightly sclerotized; basal arm thickening slightly distally; distal portion slender, tapering distally with slightly recurved tip.

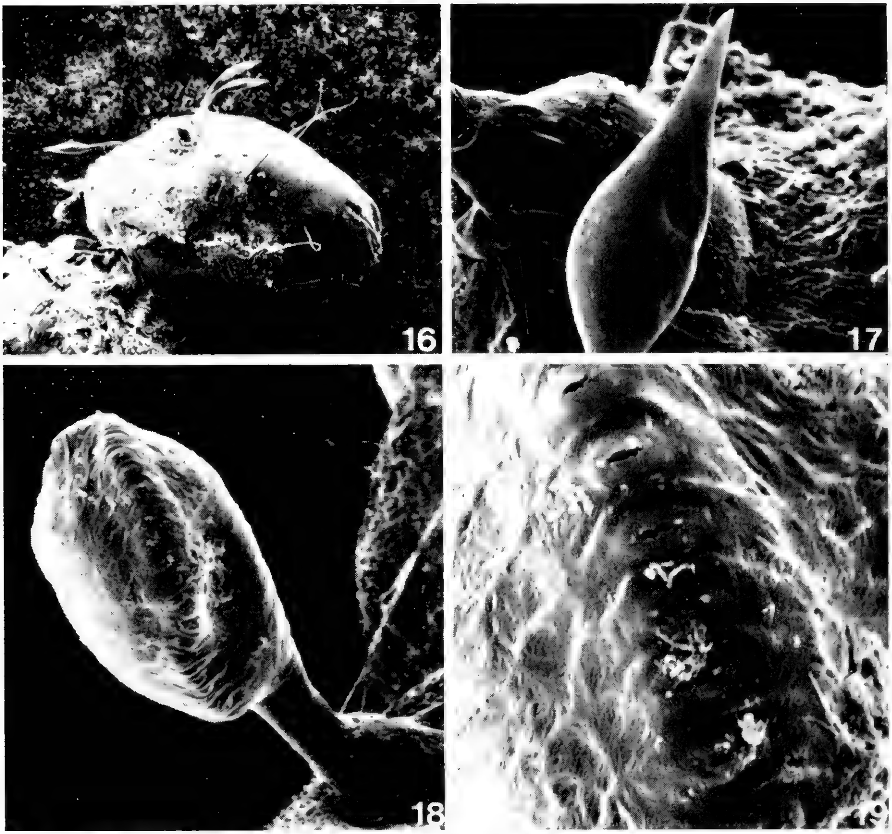
Pupa.—Retains larval exuviae. Respiratory horn (Fig. 12) with broadened base, narrowed proximally, then much broader distally; scanning electron micrograph reveals that surface is reticulate (Fig. 18), reticulations not visible in slide-mounted specimens; apex with 25–30 spiracular papillae; scanning electron micrograph reveals that apertures of papillae are much reduced (Fig. 19). Thorax with 4 pairs of dorsal setose thoracic processes; anterior pair (Fig. 13a) with terminal seta; 2nd and 3rd pair (Fig. 13b) similar but lacking terminal seta; 4th pair (Fig. 13c) similar to 2nd and 3rd but shorter; also a pair of short setose posterior processes present (not figured). Abdomen with a pair of long setose dorsal processes (Fig. 14a); a pair of short setose dorsal processes (Fig. 14b); and a slightly longer pair of setose lateroventral processes (Fig. 14c). Female terminal segment 1.6× longer than broad; surface covered with scattered fine-pointed tubercles; apicolateral processes appressed, surface wrinkled. Male terminal segment 1.6× longer than broad; surface smooth; apicolateral processes greatly appressed, surface wrinkled; ventral genital processes appressed, greatly wrinkled.

Larva (4th instar).—Body golden yellow, lightly sclerotized; internal structures of head sclerotized. Scanning electron micrograph of head (Fig. 16) indicates chaetotaxy as follows: *p* hair with broadly hastate tip; *q* hair similar to *p* hair but hastate tip slightly narrower; *t* hair long, slender; antenna 3-segmented. Prothoracic pseudopod entire; apex with 4 pairs of long sclerotized, slightly curved hooks. Midabdominal segments with hyaline, broadly hastate *a* hairs (Fig. 15a) connected dorsally by a narrow sclerotized bar to the *a* hair of the opposite side; *b* hair (Fig. 15b) heavily sclerotized, anterior sides branched; *c* hair (Fig. 15c) very short, branched on anterior side; *d* hair (Fig. 15d) twice as long as *c* hair, slightly branched on anterior side; surface of segments covered with small pointed tubercles. Terminal segment small; anal blood gills short, hyaline; anal pseudopod with double row of sclerotized hooks, 8 on each side.

Type.—Holotype, ♀, allotype, ♂, Urbana, Champaign Co., Illinois, 28.vi. and 5,12.viii.1915, on window in basement of Natural History Building, J. R. Malloch. Through the courtesy of Donald W. Webb the types were borrowed from the Illinois Natural History Survey and the allotype male was mounted on a slide for examination of the genitalia. The Plummers Island adults agreed in all respects with the types of *F. elegantula.*

Distribution.—Alberta and Saskatchewan south to Mississippi and east to Maryland; locality records plotted in Fig. 20.

New records.—ALBERTA: Medicine Hat, 30.viii.1949, L. G. Saunders,



Figs. 16–19. Scanning electron micrographs of *Forcipomyia elegantula.* 16. Larval head, 150×; 17. Abdominal *a* hair of larva, 1,150×; 18. Pupal respiratory horn, 550×; 19. Enlarged view of spiracles of pupal respiratory horn showing extremely small apertures of spiracular papillae, 2,100×.

all stages, reared from sap of black poplar tree. DISTRICT OF COLUMBIA: 3.vi.1935, A. Stone, 1♀ (pinned). KANSAS: Riley Co., ix,x.1964, N. Marston, malaise trap, 1♂, 1♀. MARYLAND: Montgomery Co., Plummers Island, 3.vi.1976, T. J. Spilman; 10.vi.1976, Wirth and Grogan; 17.vi.1976, Grogan, all stages. MISSISSIPPI: Washington Co., iv.1962, R. H. Roberts, light trap, 1♂. SASKATCHEWAN: Saskatoon, 3.ix.1950, L. G. Saunders, ex tree sap, 2♀, 1 larva, 1 pupa.

Biology.—We reared adults from pupae collected 3,10,17.vi.1976 on Plummers Island. A second generation may occur later in summer as Malloch collected specimens in Illinois in late June and again in August. The second generation would then have approximately two months to develop

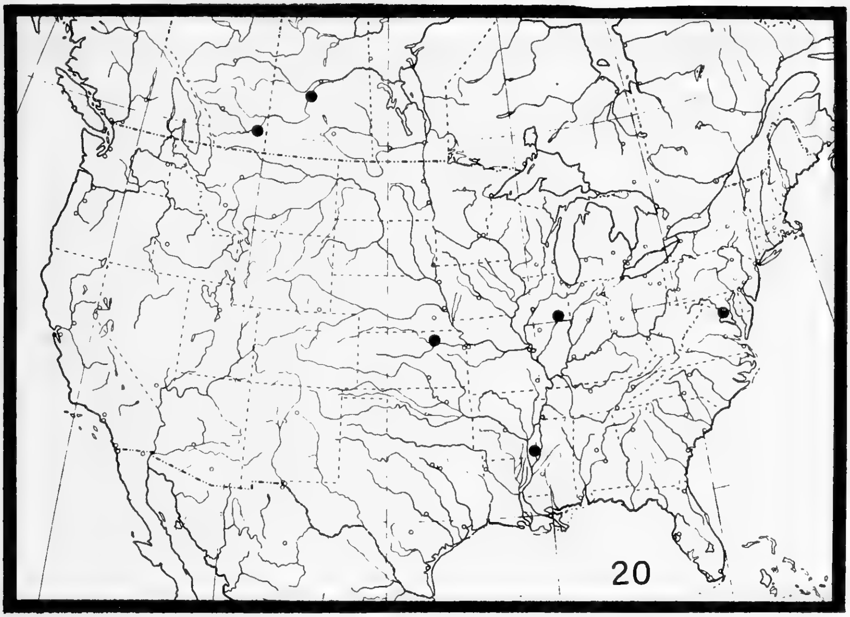


Fig. 20. North American locality records of *Forcipomyia elegantula.*

and offspring would probably be able to develop to third or fourth instars before overwintering.

We found pupae in circular aggregations of a dozen or more individuals. This behavior was observed by Saunders (1924) in many other species of *Forcipomyia* (*Forcipomyia*). Apparently during pupation they assemble in this circular manner with heads directed towards the center and tails outward. This behavior would seem to be evolutionarily disadvantageous for the species; those aggregating individuals being more or less an easily available concentration of food for any predators present. But when the larval structure and habits are studied more closely, the reason for this behavior becomes apparent.

Living larvae of *F. elegantula*, as in other species of the subgenus that have been observed, nearly always have conspicuous droplets of liquid on the tips of the hastate *a*, *p*, and *q* hairs of the body and head. According to Hinton (1955), Keilin (1918) was the first to comment on the biological significance of these modified hairs. Keilin "supposed that a hygroscopic substance on these hairs collected water from the atmosphere, which then wetted the cuticle and in some way facilitated respiration. Since the larvae are apneustic, the cuticle must be relatively permeable to air, and a hygroscopic film over the surface might be expected to tide the larvae over when exposed for short periods to lethal humidities. Keilin's explanation of the function of the setae was repeated by Saunders (1924), and Keilin (1944) quotes Saunders as an authority for the view first published by himself" (Hinton, 1955).

Frew (1923) in a very detailed anatomical and histological study of the larva of *F.* (*F.*) *picea* (Winnertz), was apparently the first to confirm the secretory nature of the hastate body hairs of *Forcipomyia.* He reported (p. 436): "The dorsolateral and dorsal setae of the body are lodged over special hypoderm cells which are enormously hypertrophied. Their nuclei differ from those of ordinary hypoderm cells in having the chromatin scattered throughout the nucleus instead of concentrated round its periphery; they contain a large nucleolus. The dorsolateral setae have a central cavity extending almost to their tips, and this cavity is occupied by an axial protoplasmic filament given off from the basal cell. In the dorsal setae the central cavity extends right to the tip of the seta in the spear-shaped head of which it becomes somewhat enlarged, the whole cavity being occupied by a protoplasmic continuation of the basal cell. It is obviously this cell which secretes the drop of liquid found at the apex of each dorsal seta in the living larva. The large cephalic setae resemble the dorsolateral body setae. The remaining setae of the body are solid and are seated upon small thickenings of the hypoderm composed of several slightly hypertrophied cells instead of one greatly hypertrophied cell. The dorsal, dorsolateral and lateral setae of the body are attached to the body wall by distinct articulations, but this does not appear to be the case for the ventrolateral setae of the minute ventral setae."

Hinton (1955) gave details of a very interesting series of experiments performed by himself and his students to investigate the nature of the substance secreted through the specialized setae. They concluded that the substance is defensive in function and appears to have no significance in respiration. Using a laboratory colony of the ant *Lasius niger* L., they found that the ants would attempt to attack larvae of *Forcipomyia* (*F.*) *nigra* (Winnertz) when the latter were placed within their enclosure. Usually, whenever the ants came close enough to bite the midge larvae, they touched one or more droplets of liquid on the hastate setae, at which time they immediately dropped the larvae and usually spent several minutes cleaning themselves. Experiments at different relative humidities showed that at low humidities, when droplets were not formed, larvae were dorpped less quickly by the ants than at high humidities when the setae had large drops on their apices. If the last larval skins were removed from midge pupae, the ants would carry the pupae to their nest; they also succeeded in carrying away pupae if they could attack them from the front and dislodge them from the larval cuticle. But if the ants approached the pupae from the side or rear, they always became smeared with the hygroscopic substance remaining on the larval cuticle and would retire and clean themselves.

When the midge pupae form their usually complete circular aggregations, they form nearly a perfect defensive barrier against such attacks by predators. The chemical nature and mode of action of the hygroscopic substance remain a mystery.

Forcipomyia (*Forcipomyia*) *pulchrithorax* Edwards
(Figs. 5, 7–11)

Forcipomyia pulchrithorax Edwards, in Saunders, 1924:209 (male, female; England; bred from larvae in tree sap, tree wounds, wood debris, etc.); Saunders, 1924:202 (larvae, pupae; from granular, solidifying sap from open wounds of elm, chestnut, and ash trees; figs.); Remm, 1961:173 (descriptive notes on male, female; figs.; Estonia); Goetghebuer, 1950:2 (Belgium; fig. male genitalia); Neindorff, 1959:31 (descriptive notes on all stages; habitat and life history notes; fig. wing; German); Zilahi-Sebess, 1940:21, 29 (Hungary; male, female redescribed; figs.); Havelka, 1976:232 (Germany; male, female diagnosis, figs.; seasonal distr.).

Diagnosis.—For detailed descriptions of all stages see Saunders (1924). *Forcipomyia pulchrithorax* is a darker species and differs from *F. elegantula* also in lacking the black band on distal ¼ of hind femur; females with pyriform spermathecae (Fig. 5); males with triangular aedeagus (Fig. 7) with a convex basal arch; pupa with a smaller tuberculate respiratory horn (Fig. 8) bearing 15–20 spiracular papillae, shorter thoracic processes (Figs. 9a–c) and shorter abdominal processes (Figs. 10a–c); larva with much smaller, slightly hastate *a* hair (Fig. 11a), shorter, stouter, doubly-branched *b* hair (Fig. 11b), stouter *c* hair (Fig. 11c), and shorter, stouter, fringed *d* hair (Fig. 11d).

Specimens examined.—AUSTRIA: Tirol, Igls, 900 m, 15.ix.1953, J. R. Vockeroth, 1♂. ENGLAND: Cambridge, 31.viii.1922, L. G. Saunders, from sap in elm wound, 1♀, 4 larvae, 5 pupae. ESTONIA: Luua, 28.viii. 1960, H. Remm, 1♂, 2♀.

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(WWW) Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560; and (WLG) Department of Entomology, University of Maryland, College Park, Maryland 20742.

NOTE

REPLACEMENT NAME FOR *DROSOPHILA NIGRICOLOR* HARDY (DIPTERA: DROSOPHILIDAE)

Drosophila nigricolor Hardy (1977. Proc. Entomol. Soc. Wash. 79(1):92) is preoccupied by *D. nigricolor* de Meijere (1911. Tijdschr. Entomol. 54: 399) and *D. nigricolor* Strobl (1898. Mitt. Naturwiss. Ver. Steiermark (1897). 34:266). I propose *Drosophila picea* Hardy as the new name for *D. nigricolor* Hardy.

D. E. Hardy, *Department of Entomology, University of Hawaii at Manoa, Honolulu, Hawaii 96822.*

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80(1), 1978, pp. 103–112

GEOGRAPHIC VARIATION IN *TACHYSPHEX TERMINATUS* (HYMENOPTERA: SPHECIDAE, LARRINAE)

Nancy B. Elliott and Frank E. Kurczewski

Abstract.—Males of *Tachysphex terminatus* (Smith) were collected from a number of populations during the summers of 1968, 1969, and 1970. Color, size and punctation characteristics were compared statistically. All individuals collected east of the Rockies had red-tipped abdomens, but many individuals from the West were all black. Increased melanization of the genitalia was evident in individuals from coastal areas, both in the East and West. There was no significant size variation, except for a sample of very large individuals from coastal California, and one of small individuals from Idaho. Samples from western Kansas consistently showed lower values for vertex punctation than many of the other samples. Additional work with museum specimens from throughout the species range has tended to substantiate many of these findings.

Geographic variation in animals has been documented for external color patterns, and morphometric, chromosomal, physiological, and ecological characters. There is much literature on geographic variation in insect groups including Collembola (Christiansen and Culver, 1968 and 1969), Orthoptera (Craddock, 1970; Masaki, 1967), Homoptera (Sokal, 1952 and 1962; Sokal and Rinkel, 1963; Sokal and Thomas, 1965), Hemiptera (Slater and Knop, 1959), Coleoptera (Mason, 1964; Willis, 1967; Young, 1960), Lepidoptera (Creed et al., 1962; Lucas, 1969), Diptera (Sokoloff, 1965), and Hymenoptera (Alpatov, 1929; Michener, 1947). Within the Hymenoptera, intraspecific variation in the Sphecidae has also been treated anecdotally as by Fernald (1926) or in taxonomic revisions, as by Bohart and Menke (1963). Our paper presents results of a study of geographic variation in the digger wasp *Tachysphex terminatus* (Smith). This wasp is found throughout North America from Alaska to Mexico, except Florida, nests in bare sand, and may be locally abundant. Areas of suitable habitat are often separated by vegetation, affording the local population some degree of isolation.

Tachysphex terminatus belongs to a group of closely related North American species of *Tachysphex* including the following: *Tachysphex apicalis* Fox, *T. fusus* Fox, *T. similis* Rohwer, *T. plesia* Rohwer and *T. linsleyi* Bohart. Group members share certain diagnostic characters, including a wide least interocular distance, relatively long erect setae on the vertex, and prominent convexities behind each posterior ocellus. *Tachysphex terminatus* may be distinguished from other group members by the following set of characteristics: a ratio between least interocular distance and head width of .29–.33, a smooth punctate frons, and an unnotched

Fig. 1. Collection localities for males for 1968, 1969 and 1970. (01) Scullville, New Jersey 1968, 12; (02) New Gretna, New Jersey 1969, 16; 1970, 13; (03) Colonie, New York 1968, 13; (04) Clifton Park, New York 1969, 20; (05) Albany, New York 1970, 14; (06) Chittenango, New York 1968, 24; 1969, 23; 1970, 20; (07) Presque Isle, Pennsylvania 1968, 7; (08) Wamego, Kansas 1969, 14; 1970, 15; (09) Lakin, Kansas 1968, 12; (10) Kendall, Kansas 1969, 25; 1970, 11; (11) Hoback Junction, Wyoming 1970, 8; (12) St. Anthony, Idaho 1970, 18; (13) Mendocino Co., California 1970, 19.

clypeus. The behaviors of several species in the *T. terminatus* group have been studied by Kurczewski (1964, 1966), allowing correlation with findings on other aspects of their biologies. There are indications that patterns of geographic variation could complicate taxonomic studies of the group. Western individuals of *T. terminatus*, for example, appear superfically different from their eastern conspecifics. The range of morphological variation in each species is unknown, and it is desirable to study the extent of variation in each, before undertaking further ethological or taxonomic studies.

Methods and Materials

Adults were collected during the summers of 1968, 1969, and 1970. Collection localities are shown in Fig. 1. Preliminary comparisons between successive generations in a single locality (Chittenango, New York) in 1968 revealed significant mean differences in several characters for females, but not for males (Elliott and Kurczewski, 1974a). Since seasonal variation might complicate the study of geographic variation, only males were collected for the remainder of the study. Specimens from museum collections were used to supplement data based on field-collected specimens for localities from which samples of five or more males were available. The collections localities for museum specimens and the number of specimens for each locality are as follows: Ithaca, New York (23); southern New Jersey (24); Riley and Pottawatomie Co., Kansas (13); Wisconsin (19); Lewisville, Arkansas (12); Kill Devil Hills, North Carolina (13); Virginia (10); Galveston, Texas (12); Mendocino Co., California (5); San Francisco, California (18); Lassen Co., California (9); St. Anthony, Idaho (6); southern Quebec (12).

Measurements and counts on specimens were made using a binocular dissecting microscope with a grid and ocular micrometer. A factor analysis on 18 morphometric characters indicated head width was a good indicator of general size. Of the characters which loaded heavily in size, it was the easiest to measure accurately (coefficient of reliability = .999 for remeasurements). For this reason it was compared as a general size measure throughout the remaining analyses. Puncture counts per grid unit on the vertex were transformed for statistical analysis by computing the mean of the square root of the two counts on each individual. Genitalia were removed from males collected in 1970, mounted on slides, and the color of the volsella, coded on a scale from 1–3 (light–dark), was recorded. The percent of each sample with red-tipped abdomens was also recorded.

Variation between annual samples was tested with one-way analysis of variance for size-related characters and puncture counts. Homogeneity of variances was first tested with Bartlett's Test (Sokal and Rohlf, 1969:370). For homogeneous variances, means were tested with Model 1 ANOVA to show actual mean differences, and variation was also partitioned into that due to variation within and between groups (Model 2 ANOVA). An F approximation was applied for unequal variances (Sokal and Rohlf, 1969: 372). Multiple comparisons were made with Student-Newman-Keuls Test (Sokal and Rohlf, 1969:242).

Results

Table 1 shows partition of variance (Model 2 ANOVA) for samples and years. During 1968 and 1969, when all samples were collected east of the Rockies, there was no significant size-related variation. In 1970, when populations from the West were also included, the Model 1 ANOVA indicated significant differences for head width ($F = 9.55$; $P < .05$). The distribution of probit means for head width in 1970 is shown in Fig. 2A. This distribution was characteristic of those for a number of size-related characters (Elliott, 1971). The lowest mean value, that for a sample from St. Anthony, Idaho, was significantly different from those values for

Table 1. Partition of variance in *Tachysphex terminatus.*[1]

Characters	% Variance (localities)	% Variance (individuals)
1968		
Head width	1.05	98.90
Punctation/vertex	34.35	65.65
1969		
Head width	.64	99.35
Punctation/vertex	26.00	74.00
1970		
Head width	37.36	62.64
Punctation/vertex	12.15	87.85

[1] Summaries of ANOVAs may be obtained from senior author.

all other samples except the one from southern New Jersey. The highest value, from Mendocino Co., California, was significantly different from all others, except that from western Kansas. Museum samples showed similar trends in geographic variation ($F = 3.34$; $P < .05$; see Fig. 2B). But differences in sample size made it difficult to demonstrate statistical significance in the multiple comparisons tests. Means for head widths for specimens from Mendocino County still ranked among the largest, along with those for specimens from Wisconsin and Quebec. Many of the smaller specimens were from St. Anthony, Idaho. Some of the larger males among the museum specimens were from Mendocino Co., California, while some of the smallest came from nearby San Francisco.

Vertex punctation varied significantly during all years of the study (in 1968, $F = 8.77$; $P < .05$; in 1969, $F = 7.70$; $P < .05$; in 1970, $F = 2.96$; $P < .05$). (See Fig. 3.) In 1968, samples from Colonie, New York and Presque Isle St. Park, Pennsylvania, had the lowest mean values for this character. These values were significantly different from those for central New York samples. A low mean value for this character in the sample from western Kansas was significantly different from the means from central New York samples. In 1969, the western Kansas sample had a significantly lower value for this character than all other samples. In 1970, the sample from this locality again had the lowest mean value for the character, and a sample of individuals from St. Anthony, Idaho had a significantly higher mean value for the character than all other samples.

All specimens collected in the East during 1968 and 1969 had red-tipped abdomens. In 1970, a number of all black males were collected from the West. None of the males from Mendocino Co., California were red-tipped;

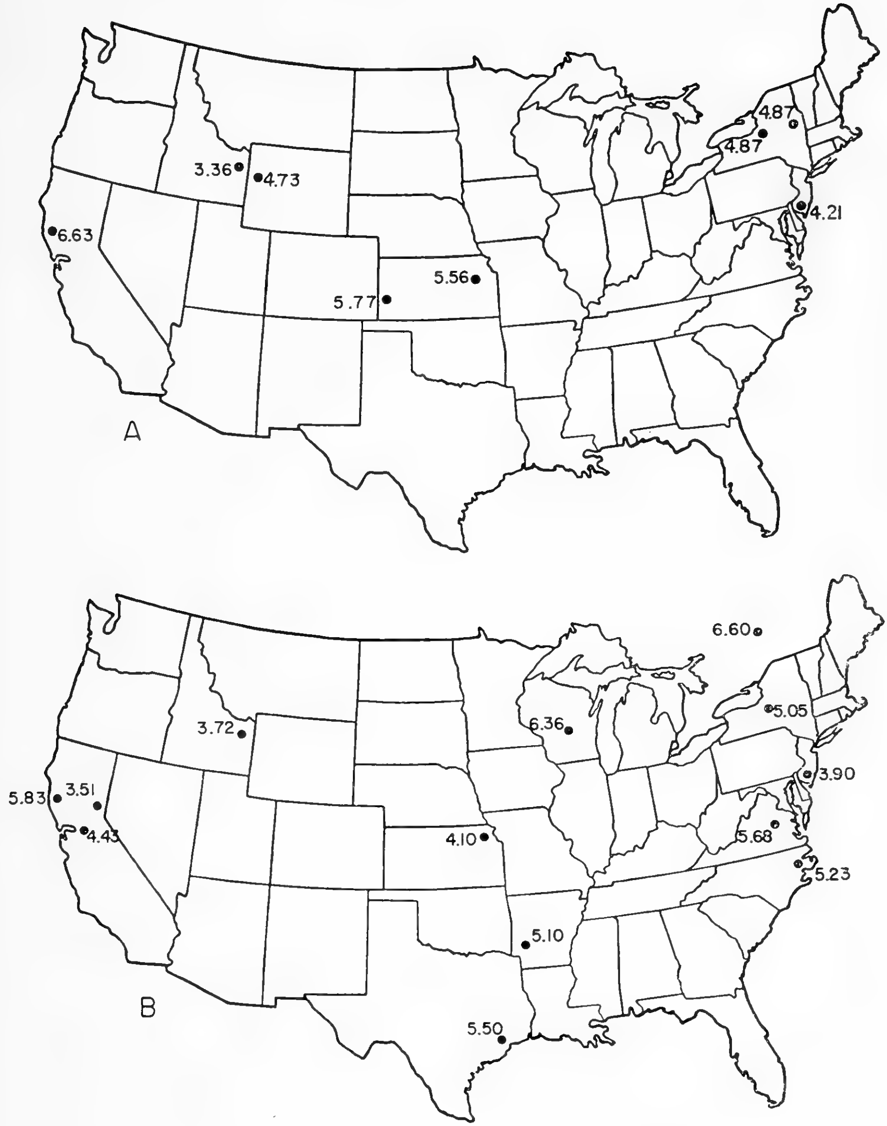

Fig. 2. Size variation in *Tachysphex terminatus* males.

A. Distribution of probit means for head width in 1970 samples. SNK Test: 3.36 4.21 4.74 4.87 5.56 5.77 6.63

B. Probit means for head width in museum specimens. SNK Test: 3.52 3.72 3.90 4.10 4.43 5.05 5.10 5.23 5.50 5.68 5.82 6.36 6.60

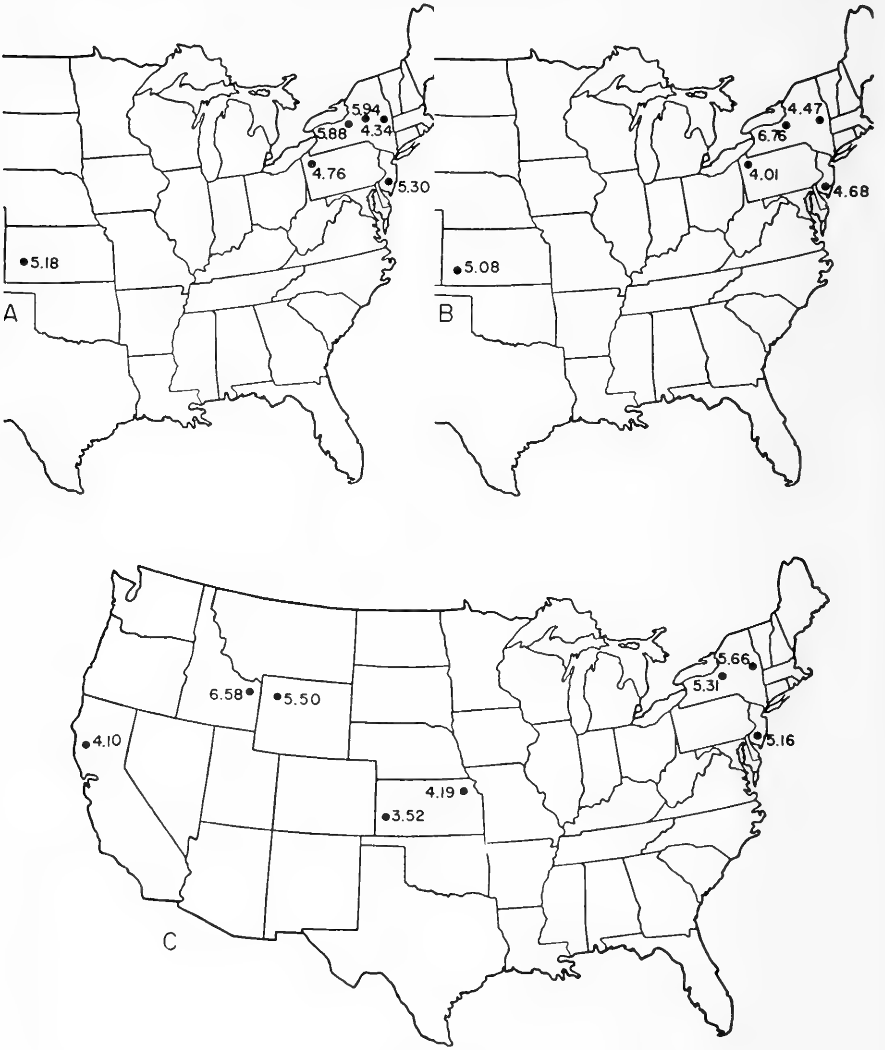

Fig. 3. Probit means for vertex punctation.

A. 1968 samples. SNK Test:
3.89 3.94 5.50 5.82 5.84

B. 1969 samples. SNK Test:
3.34 4.75 4.85 5.28 5.40 6.38

C. 1970 samples. SNK Test:
3.52 4.09 4.20 5.16 5.31 5.50 5.66 6.59

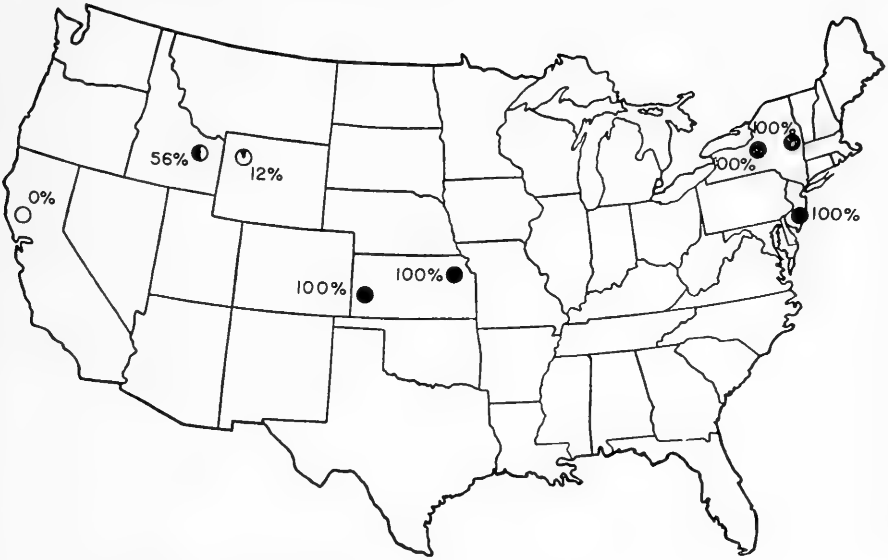

Fig. 4. Percentages of 1970 samples with red-tipped abdomens.

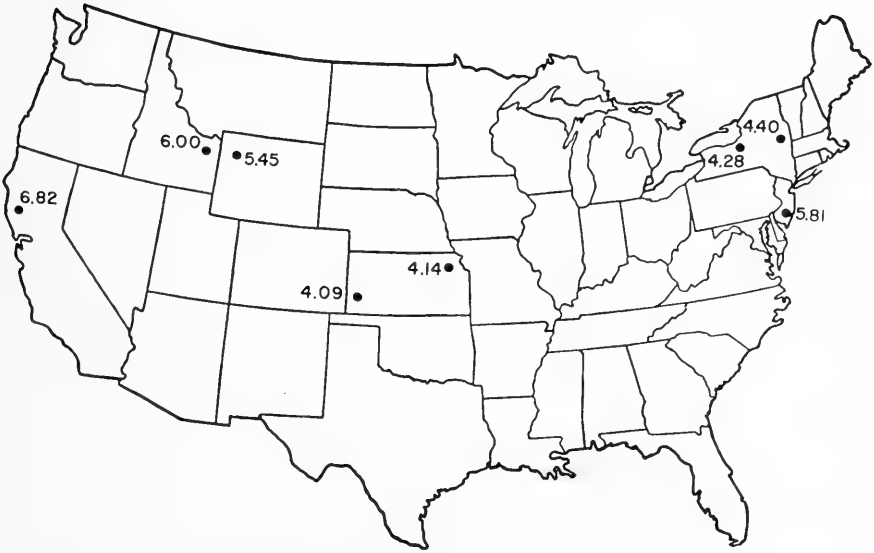

Fig. 5. Distribution of probit means for volsella color (1970).

56% of the Idaho males and 12% of the males from Wyoming were red-tipped. Figure 4 shows the distribution of red-tipped males in the 1970 field samples. Similar patterns were evident in museum specimens. All males from the East were red-tipped, whereas males from western localities were frequently all black. Among museum specimens, there were no red-tipped males from St. Anthony, Idaho or Mendocino Co., California, while 63% of the males from Lassen Co., California and 11% of those from San Francisco were red-tipped.

All black specimens showed the greatest degree of melanization on the volsella, with those from coastal California having the darkest volsellae (Fig. 5). The greatest melanization in red-tipped males occurred in specimens from coastal New Jersey. In fact, they showed more melanization than all black males from Wyoming.

Discussion

The most distinctive geographic patterns in size variation showed in samples collected in 1970. Excluding the samples from Idaho and Wyoming, there seemed to be a cline of increasing size from the smallest individuals collected near coastal New Jersey to the largest individuals from the California coast. Specimens from Idaho and Wyoming, which were smaller than those from other localities, seemed to show a second effect acting upon size, possibly related to altitude. These localities had the highest altitudes of any sampled (4,900′ and 6,000′, respectively). Thus an inverse relationship between size and altitude appeared to be superimposed on the general clinal pattern of increasing size from east to west. While no distinct longitudinal cline of size showed up in museum samples, the inverse relationship between size and altitude was indicated. The smallest specimens came from Lassen Co., California, at an altitude of approximately 5,000′. The fact that specimens from western Kansas consistently exhibited relatively sparser vertex punctation than those from other areas seemed to indicate selection acting on this or a related character. High density in vertex punctation in the Idaho specimens, which were the smallest individuals, suggested a predictable inverse relationship with size. The most obvious variation in *T. terminatus* was in abdomen color. Western males were often all black, although females occurring with them were frequently red-tipped. Males from coastal California conformed to the stereotype of specimens from coastal climates (see Fernald, 1926). They were large and dark with much melanization on the volsella. Coastal New Jersey wasps, although smaller and red-tipped, also showed increased melanization on the volsella, presumably an effect of moist coastal climates. Elliott and Kurczewski (1974b) have already reported that the presence or absence of potential competitors in the habitat may affect the morphology of related *Tachysphex* species. The present study suggests that a number of environmental factors act independently to produce morphological variation throughout the range of *T. terminatus*. These factors may include effects of altitude in relation to size, humidity to increase melanization in coastal environments, and various effects acting on punctation characteristics throughout the range.

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Department of Entomology, SUNY College of Environmental Science and Forestry, Syracuse, New York 13210.

Present address.—(NBE), Department of Biology, Hartwick College, Oneonta, New York 13820.

NOTE

NEW SYNONYMY IN *NERTHRA* SAY (HEMIPTERA: GELASTOCORIDAE)

Two specimens of predaceous bugs of the family Gelastocoridae intercepted in Miami, Florida in an air shipment of ferns from Colombia on 22 August 1975 by F. Matthews confirm a suspected synonymy (Todd. 1955. Univ. Kans. Sci. Bull. 37(1), no. 11, p. 389). The specimens, a male and a female, represent respectively *Nerthra ater* (Melin, 1929) and *Nerthra rudis* (Melin, 1929) described in Zoologiska Bidrag Fran Uppsala, Band 12, p. 185 and p. 182. In 1955 I suggested that if the two names did apply to the two sexes of one species, *Nerthra ater* (Melin, 1929) would fall as the junior synonym. This comment was based on the concept of page priority current at that time. Since the shape of the male paramere is a better recognition character than the overlapped basal part of the right ovipositor lobe of the female, I place *Nerthra rudis* (Melin, 1929) as the junior synonym of *Nerthra ater* (Melin, 1929) [New synonymy].

E. L. Todd, *Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.*

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ETHOLOGY OF *CEROTAINIA ALBIPILOSA* CURRAN (DIPTERA: ASILIDAE) IN MARYLAND: PREDATORY BEHAVIOR[1]

A. G. Scarbrough

Abstract.—A field study of the predatory behavior of *Cerotainia albipilosa* Curran is reported. The asilid foraged from leaves and stems of sunlit plants found along the margins of clearings and paths. The forage flight patterns are discussed. Only 14% of the flights were successful. Most prey (93%) were captured within 2 m of foraging sites. *Cerotainia albipilosa* exhibited specialized methods for capturing prey. The hypopharynx was inserted into the dorsum or one end of the body. The asilid immobilized prey in the air before returning to foraging sites. Individual feeding times averaged 5 minutes but varied considerably depending on prey characteristics and weather conditions. Interfeeding times ranged from 0–35 minutes. While feeding, the asilid frequently hovered in front of a perch and manipulated the prey. Over 94% of the prey belonged to five insect orders (Diptera, Coleoptera, Hymenoptera, Psocoptera and Hemiptera–Homoptera) and 67% to two (Diptera and Hemiptera–Homoptera). Prey were usually soft-bodied, weak flyers and averaged 1.6 mm in length and 0.05 mg in weight. Females captured larger prey than males. Mean predator to prey size and weight ratios were 3.7 and 7.3, respectively. Several factors which influenced prey selectivity are discussed. This asilid was sometimes preyed on by spiders, vespid wasps and other asilids.

In the first part of this study, Scarbrough and Norden (1977) reported on the diurnal activity rhythm and seasonal distribution of *Cerotainia albipilosa* Curran in Maryland. They reported that most of the species flight activities were centered around predation and reproductive behaviors. The purpose of this paper is to report on the predatory behavior of the species. A third paper will deal with reproduction.

Methods and Procedures

General methods and procedures for observations made in the field and the study site were described in a previous paper (Scarbrough and Norden, 1977). Observations were recorded in a notebook at the study site or on a Sanyo solid state tape recorder model 2212 and were later transcribed into a notebook. When possible, photographic records of different behaviors were taken. A Honeywell Pentax 35 mm, single lens reflex camera in conjunction with telephoto lenses and extension tubes was used to obtain close-up pictures.

Collections of prey were made during the summers of 1973 and 1974. Care was taken to collect prey from each segment of the species diurnal activity period through the season to obtain a maximum variety of prey types. Most prey were obtained by capturing asilids seen with prey with a 15 dram snap top vial as I walked through an observation site. The asilid usually ceased feeding immediately and dropped the prey in the vial, although some continued to feed, only to drop them at a later time. This procedure minimized damage to prey specimens. Once the prey was dropped, the asilid was identified and usually released. Some prey were recovered from leaves below feeding sites where asilids had dropped them. The prey were then transferred to vials containing 70% ETOH with the following information: Sex of predator, date, location, and collector.

Prey were analyzed by making two types of body measurements: Size and weight. To determine prey size, each specimen was measured for total body length to the nearest 0.5 mm using an ocular micrometer. From a reference collection made at the study site, prey of selected lengths were oven dried to 38°C for 30 minutes and weighed to the nearest 0.01 mg. Similar measurements of the asilid were obtained by measuring and weighing ten specimens in the same way as described for prey.

Some prey were identified by the author with the aid of the collection housed at the Towson State University Museum. However, most prey were shipped to the Systematic Entomology Laboratory (SEL), IIBIII, Agric. Res. Serv., USDA, Beltsville, Maryland and to the Smithsonian Institution (SI), Washington, D.C. A few specimens were also identified by recognized specialists in other parts of the country.

Results and Discussion

Foraging and feeding.—Cerotainia albipilosa foraged under bright skies from leaves and stems of vegetation along margins of clearings and paths, and at air temperatures above 19°C (Scarbrough and Norden, 1977). These flies were usually active on foraging sites, rapidly turning their bodies to face one direction and then another. Each movement was preceded by quick movements of the asilid's head as potential prey flew in front of or to the side of the foraging site. Presumably this behavior enables the asilid to better perceive potential prey and, at the same time, it is in a more suitable position to make a direct forage flight (Dennis and Lavigne, 1975). Similar foraging behavior is exhibited by *Stichopogon trifasciatus* Say (Lavigne and Holland, 1969) and by several species of *Holopogon* (Lehr, 1972; Dennis and Lavigne, 1975).

Most foraging flights were directed toward potential prey in the air after they flew near the asilid. Upon perceiving prey, the asilid "leaped" into the air, flew at an oblique angle to the prey's path, converged and intercepted it a short distance from the foraging site. Prey were usually captured at the same height or slightly above the foraging site. Adjustments in flight patterns occurred once the asilid took flight. In most cases, after leaving a perch, the asilid's flight path was initially below the prey, although a noticeable elevation in its flight was detected near the interception point. Such behavior facilitated capture, and subsequent immobilization of the prey, in flight. The asilid also compensated for overestimations of flight speed of prey by looping about 5–7 cm above the prey's path, hesitated in this position, and then attacked as the prey passed below at the interception point. They frequently flew toward potential prey only to turn away a few cm from foraging sites or near the interception points. Dennis and Lavigne (1975) termed these flights "investigatory" since they permit discrimination between unsuitable and suitable prey before actually attacking. In a few cases the asilid fluttered its wings and tilted the body forward without leaving a perch in response to passing insects. Unless disturbed, the asilid returned to the same foraging site following each flight.

Females of *C. albipilosa* often flew after insects and falling objects that were several times (>3×) larger than themselves. Several females on separate occasions foraged after butterflies (*Pipilio glaucus* L.) and ichneumonid wasps (*Ophion* sp.), but invariably they turned away from them near the interception points. Two other females attempted to capture a halictid bee (*Augochloropsis* sp.) and a Japanese beetle (*Popillia japonica* Newman). They attacked the insects and held onto their wings for about 1–2 seconds before releasing their grasps and returning to foraging sites. Falling leaves were also frequently pursued by females. Similar observations of asilids flying toward falling objects have been reported by other investigators (Melin, 1923; Parmenter, 1952).

Foraging flights were directed at potential prey flying within a range from 8 cm–4 m in front of or to one side of a perched asilid. Most flights occurred when prey were within 2 m of foraging sites. Flights that resulted in prey captures were made when prey were at the following distances from foraging sites: 68% at 8 cm–1 m, 25% at 1–2 m and 7% at 2–4 m. Ninety percent of the capture flights within 1–20 cm resulted when prey flew from the vegetation and to one side of a perched asilid. Prey captured at greater distances were invariably flying in front of foraging sites. Furthermore, prey captured beyond 2 m by females were characteristically large (>3 mm) whereas those taken at closer ranges represented all size classes. Males captured smaller prey (<2 mm) and were rarely successful (<1%) beyond 2 m. Thus, it is assumed that the visual capability of *C. albipilosa* is more acute at short range.

Few foraging flights resulted in prey capture. Only 14% of the flights were successful regardless of distances from foraging sites. However males

Fig. 1. *Cerotainia albipilosa* feeding on *Aleurochiton* sp. (Hemiptera–Homoptera: Aleyrodidae).

were more successful than females with 17% and 11%, respectively. This forage success differential is directly related to disruptions of the female's foraging behavior caused by courting and mating males (Scarbrough and Norden, 1977) and to females foraging longer distances in pursuit of larger prey than males. It is also interesting to note that if these flights were separated into no-contact flights (investigatory) and contact-flights (foraging), as defined by Dennis and Lavigne (1975), then foraging success is much greater (91%). Nevertheless, if one considers the amount of energy which is expended in foraging (investigatory and contact flights), the tendency to fly after most moving objects appears to be quite wasteful. At the same time, since asilids can probably detect only a rough outline of a moving dark body (Melin, 1923), this behavior would maximize the probability that they pursue and capture suitable prey.

Like many asilid species (Dennis and Lavigne, 1975; Shtakel'berg, 1950; Fackler, 1918; Horning and Barr, 1970; Scarbrough and Sipes, 1973; Schmid, 1969; Wallis, 1913; Zinov'era, 1959), *C. albipilosa* has specialized methods of capturing prey and common sites for inserting the hypopharynx. The asilid usually captured prey along their dorsolateral surfaces, and impaled them on the dorsum or at one end of the body (Fig. 1). Large bodied insects with hard wings, i.e. the first pair of wings of beetles and cicadellids, were captured with their wings extending in a flight position, exposing the soft underlying integument. The hypopharynx was inserted into this area, usually near the junction of the thorax and abdomen. Staphylinid beetles and formacine ants were similarily impaled through thin or soft areas of the integument; i.e. eyes and conjunctiva between sclerites at the end of the abdomen. The remaining prey had "soft" integuments, and the hypopharynx was inserted at various places on the dorsum.

Once prey were captured, *C. albipilosa* usually immobilized them in the air before returning to foraging sites. Most immobilizations occurred in flight as soon as they were captured. When prey were large (>2.0 mm), the asilid hovered in front of the foraging site, manipulated them using all six tarsi, and inserted its hypopharynx. Immobilizations were rare events at foraging sites since only one successful and four attempts were observed in over 1,200 observation hours. In these instances, the asilids landed on a leaf, fell on one side, and used all six tarsi to manipulate the prey. The prey were large, and these behaviors were preceded by unsuccessful immobilizations in the air before landing.

Like other asilid species (Dennis and Lavigne, 1975), *C. albipilosa* sometimes foraged with prey impaled upon its hypopharynx. On several occasions the asilids returned with two prey impaled upon their mouth parts, one was the original and the second a new prey. The hypopharynx had been forced completely through the former, and the latter was projecting from its apex. Usually when two prey were captured, the last captured was lost or dropped during manipulation.

Unless disturbed, *C. albipilosa* remained at its initial foraging site until feeding was completed. Males were more "nervous" than females and were easily disturbed. When feeding was completed, the asilid moved its fore tarsi in alternating sequences and disengaged the prey from the hypopharynx. Prey were also discarded by the asilid in flight for another prey, but without using its tarsi. Other investigators (Lavigne and Holland, 1969; Dennis and Lavigne, 1975) have also observed this behavior and have suggested that the hypopharynx is merely retracted into the labrum, allowing gravity to "pull" the prey off the proboscis. While feeding, the asilid continued to observe other moving "prey" which flew near its perch with rapid movements of the head and body.

When feeding, *C. albipilosa* frequently hovered in front of a perch and manipulated the prey. The asilid used all six tarsi to disengage, to rotate and to re-insert the hypopharynx at a new location in the prey. It then returned to the feeding site, re-oriented its body into a foraging position and continued to feed. Prey were sometimes dropped during manipulation in which case the asilid usually returned to the foraging site. However foraging flights were occasionally initiated from the hover position when prey were dropped. The mean time for manipulating prey was 6.1 seconds.

Cerotainia albipilosa fed on prey for an average of 5 minutes. The length of individual feedings varied considerably, ranging from 1–81 minutes depending upon the size and shape of prey and weather conditions. Aphids such as *Aphis* sp., *Macrosiphum* sp., and *Myzus* sp., which had soft bulbous bodies and average lengths of 2 mm, were fed on for 1–2 minutes. Dipterans and psocopterans, which also had similar integuments and average body lengths, had tubular shapes and were fed on for an average of 3 minutes. Larger prey, such as reproductive ants (*Ponera pennsylvanica* Buckley and *Lasius* sp.) which have hard exoskeletons and constricted "waists," were fed on for an average of 20 minutes. The asilid frequently manipulated them and alternated the points at which the hypopharynx was inserted from the eyes to the ends of their abdomens. In other large hard bodied prey, such as *Gymnetron pascuorum* (Gyll.) and *Pseudopentarthrum* sp. (Colopetera: Curculionidae) and *Macrosteles* sp. (Homoptera: Cicadellidae), the hypopharynx was alternated from the dorsum below the elytron to the end of the abdomen. Manipulations of aphids, dipterans, psocopterans and other prey with similar body characteristics were rarely observed. Weather conditions frequently influenced the duration of feeding. One asilid fed on *Ponera pennsylvanica* (3.0 mm) for 81 minutes under overcast skies. Feeding on various prey of a similar size under sunlit conditions ranged from 10–20 minutes. Similar observations were reported by Dennis and Lavigne (1975).

The average interfeeding time for *C. albipilosa* was 6 minutes with a range between 0 and 35 minutes. The 0 minute interfeeding time was for individuals who dropped prey and immediately captured new ones. Based upon this data, the average time for a complete feeding and the average 9 hr foraging period, *C. albipilosa* could theoretically feed on a maximum of 49 prey/day. These calculations, like those reported for other asilid species (Lehr, 1964; Musso, 1971; Dennis and Lavigne, 1975, 1976a, 1976b), overestimate the number of prey fed upon by this asilid, since it did not forage and feed continually but often engaged in other activities such as courtship and mating (Scarbrough and Norden, 1977). A more reasonable estimate would be 25–30 prey/day.

Prey.—Most prey of *C. albipilosa*, like other aslid species (Hobby, 1931; Brues, 1946; Poulton, 1906; Cole and Lovett, 1921; Melin, 1923; Dennis and Lavigne, 1975), belong to a few orders of insects. Of the ten orders of prey recorded for this species, over 94% belong to five insect orders and formed 98% of the prey dry weight (Table 1). Prey belonging to Diptera and Hemiptera–Homoptera formed the major prey orders, comprising over 67% of the prey captured and 63% of the prey dry weight. The orders Coleoptera, Hymenoptera and Psocoptera were less significant, forming 27.4% of the total number of prey and 34.1% of the prey dry weight. These results are consistent with prey availability. When sweep samples ($N = 25$) of vegetation were taken at various times at the study sites, Diptera and

Table 1. Dietary composition of *Cerotainia albipilosa* at the Loch Raven Watershed in Baltimore County, Maryland.

Order	No. prey	Percentage prey	Dry weight (mg)	Percentage total dry wt.
Diptera	274	37.1	8.2	24.1
Hemiptera–Homoptera	225	30.4	13.5	39.7
Hymenoptera	88	11.9	3.5	10.3
Coleoptera	60	8.1	4.2	12.3
Psocoptera	55	7.4	3.9	11.5
Others	37	5.0	0.7	2.0
Totals	739		34.0	

Hemiptera–Homoptera were more abundant per sample than other prey orders ($\bar{x}$/sample; 31.9% Diptera; 39.3% Hemiptera–Homoptera; 19.8% Coleoptera, Hymenoptera, Psocoptera; 9.0% others).

The major prey orders consisted of a wide diversity of species and families (see list of prey). At least 56 and 63 species belonged to 15 and 10 families of Diptera and Hemiptera–Homoptera, respectively. In Coleoptera, Hymenoptera and Psocoptera, the prey consisted of a relatively small number of species (20, 25, 8, respectively) but belonged to several families (12, 13, 7, respectively). It is also interesting to note that within the two major orders, most prey belong to three categories. Over 61% of Diptera belong to Nematocera, and at least 62% of Hemiptera–Homoptera belong to Cicadellidae (22%) and Aphididae (40%). These results were not surprising since the majority of the prey are some of the most abundant plant feeders inhabiting woodland ecosystems.

The average prey captured by *C. albipilosa* was 1.6 mm in length and 0.05 mg in weight (Table 2). The mean predator to prey size and weight ratios were 3.7 and 7.3, respectively. However prey varied considerably ranging from 1–4 mm in length and from 0.01–0.12 mg in weight. Males were rarely found with prey larger than 2 mm in length and 0.09 mg in weight whereas females were found with prey of all class sizes. Most of the prey of males belonging to Diptera, Hemiptera–Homoptera and Hymenoptera consisted of nematocerans, aphids and Apocrita parasitoids, respectively. In addition to the latter prey, females captured a disproportionately greater sample of larger prey, i.e. cicadellids and reproductive formicids, than males.

The tendency of several asilids to capture and feed upon soft-bodied insects is assumed to be directly related to the inability of weak mouth parts to penetrate hard cuticles (Melin, 1923; Martin, 1968; Dennis and Lavigne, 1975). The predaceous behavior and prey records of *C. albipilosa*

Table 2. Mean body lengths and weights of prey arranged according to the sex of the predator.

Orders of prey	Predator sex[A]					
	$\bar{x}$ prey lengths (mm)			$\bar{x}$ prey dry weights (mg)		
	Male	Female	Both sexes	Male	Female	Both sexes
Diptera	1.4	1.5	1.4	0.02	0.03	0.03
Hemiptera–Homoptera	1.6	2.0	1.9	0.05	0.07	0.06
Hymenoptera	1.3	2.1	1.8	0.01	0.06	0.04
Coleoptera	1.8	1.7	1.7	0.06	0.07	0.07
Psocoptera	1.4	1.5	1.5	0.06	0.07	0.07
Miscellaneous	1.4	0.7	1.0	0.02	0.02	0.02
Means	1.5	1.7	1.6	0.04	0.05	0.05

[A] Predator lengths (mm) 5.6 ♂♂, 6.4 ♀♀; weights (mg) 0.23 ♂♂, 0.43 ♀♀.

support this assumption. Over 73% of the prey were soft-bodied. Among the remaining prey, which included Coleoptera, Hymenoptera, Strepsiptera and Cicadellidae, the predator utilized specific techniques to capture and to immobilize them. The hypopharynx was invariably inserted in areas where the cuticle was thin or soft.

Other investigators (Lehr, 1958; Hobby, 1931; Dennis and Lavigne, 1975) have suggested that differences in predatory habits of the two sexes were the result of temporal segregation of activity patterns, and differential densities and nutrition requirements of females. This study supports these suggestions. Males of *C. albipilosa* spend less time foraging and feeding in afternoons, and more time searching for and mating with females (Scarbrough and Norden, 1977). Females foraged throughout the day, and thus were found more frequently with prey than males. Furthermore several prey types captured by females were active and abundant at times when males were involved in other activities. Females captured most of the coleopterans and psocopterans between 1:00 and 4:00 PM. Flying reproductive ants swarmed and were captured during hot humid afternoons which were preceded by rain. Females, which had well-developed ovaries, evidenced by the presence of numerous eggs, weighed much more than an equal number of males ($N = 20$, $\bar{x} = 0.43$ mg ♀♀, 0.23 mg ♂♂). However, females whose ovaries and eggs were removed by dissection, weighed about the same ($N = 20$, $\bar{x} = 0.28$ mg) as males. Thus the difference in body weights of the sexes is indirectly related to differences in predatory habits. Females must spend more time foraging and feeding to obtain additional nutrition for the continuous production of eggs.

Movement of prey evokes feeding behavior in numerous predatory animals, provided that the object falls within certain size limits (Marler and Hamilton, 1956). Melin (1923) suggested that the vision of asilids is not well developed and that they perceive prey as dark moving objects. *Cerotainia albipilosa* appears to be "programmed" to forage after almost any small moving object that passes near its perch. Motion of insects in flight and falling leaves were sufficient to stimulate the asilid to leave a perch in pursuit. All prey, except spiders, were winged and captured in flight. The spiders were immature, and in effect "flying" since they were either "ballooning" or moving at the ends of suspended silk threads. Wings of most prey were large and extended to or beyond their bodies. Furthermore, prey moving in front of a perched asilid interrupt the rays of light, casting a shadow upon itself. The fluttery motion produced by large wings of soft-bodied prey, together with a dark shadowed body, greatly increase the total size of the prey's body, and undoubtedly form the major cues which stimulate the asild to leave its perch in pursuit.

A few asilid species are apparently capable of utilizing color to select prey (Linsley, 1960; Bohart, 1958). Dennis et al. (1975) showed that when *Efferia frewingi* Wilcox was presented with black, orange and white models of various sizes and shapes, the asilid responded preferentially to black, oblong ones. However use of colors to select prey by *C. albipilosa* was not detected. Color of prey integuments varied considerably, ranging from light yellow to dark brown. Color detection would be difficult at best and probably could not occur until the predator was about to, or was in contact with the prey because 1) the flight path of the asilid is slightly below that of the prey until the two arrive at the interception point, and 2) the asilid approaches the prey on its shadowed side.

The following is a list of prey taken by *C. albipilosa* at the Lock Raven Watershed, in Baltimore County, Maryland. All prey were collected at the study site between 30 June and 30 August of 1973 and 1974. In some instances prey is presented only to the order or family level since specific identifications are not yet available. Each notation of prey refers to a single record in the list of prey unless followed by a number in parentheses. All prey are adults except for Araneida. W. B. Peck (Araneida); D. R. Smith (Isoptera); E. L. Mockford (Psocoptera); K. O'Neill (Thysanoptera); J. L. Herring, L. M. Russell, J. P. Kramer, R. C. Froeschner (Hemiptera–Homoptera); C. W. Sabrosky, W. W. Wirth, R. J. Gagné, G. C. Steyskal, L. Knutson (Diptera); A. S. Menke, B. D. Burks, P. M. Marsh, D. R. Smith (Hymenoptera); D. M. Anderson, R. E. Warner, R. E. White. J. M. Kingsolver, P. J. Spangler (Coleoptera); D. R. Davis (Lepidoptera); are thanked for the identification of their respective groups. Froeschner, Spangler and Peck are with the Smithsonian Institution.

Prey captured by *C. albipilosa.* ARANEIDA, Unidentified (1) 31.VII.74;

Theridiidae, *Oecobius* sp. 7.VII.73; Linyphiidae (2) 31.VIII.74; Araneidae (2) 31.VII.74; Agelenidae (3) 30.VII.74, 1.VIII.74, 3.VIII.74; Clubionidae, Clubioninae (3) 31.VII.74; Thomisidae, Philodrominae (2) 31.VII.74, 12.VIII.74; Salticidae (3) 10.VII.74, 16.VII.174, 17.VII.74; ISOPTERA, Rhinotermitidae, *Reticulitermes flavipes* (Kollar) (6 winged reproductives) 1.VII.73; PSOCOPTERA, Amphipsocidae, *Polypsocus corruptus* (Hagen) 16.VII.74, 30.VII.74; Caeciliidae, *Caecilius aurantiacus* (Hagen) 19.VII.74, 31.VII.74, 6.VIII.74; Ectopsocidae, *Ectopsocopsis cryptomeriae* (Endln.) (2) 20.VII.73, (7) 12.VII.74, (9) 17.VII.74, (2) 22.VII.74, (3) 1.VIII.74, (2) 3.VIII.74; Lachesillidae, *Lachesilla pallida* (Chapman) (1) 20.VII.74; Peripsocidae, *Peripsocus quadrifasciatus* (Harris) (1) 1.VII.73; *P. alboguttatus* group (1 sp.) 30.VI.74; Philotarsidae, *Aaronella* sp. (2) 15.VII.74, (2) 19.VII.74, (7) 31.VII.74; Psocidae, *Trichadenotecnum alexanderae* Somm. 19.VII.73, 2.VIII.73, 19.VII.74; Unidentified (2) 16.VII.74, 31.VII.74, 2.VIII.74, 15.VIII.74: THYSANOPTERA, Aeolothripidae, *Acolothrips vittipennis* Hood (2) 9.VII.74, Thripidae *Frankliniella tritili* (Fitch) 10.VII.74, *F. runneri* (Morgan) 12.VII.74, *Anaphothrips obscurus* (Mueller) 15.VII.74, *Limothrips cerealium* (Haliday) 16.VII.74, *Chaetanaphothrips* sp. near or = *orchidii* (Moulton) 17.VII.74, Unidentified 19.VII.74, Phlaeothripidae, *Leptothrips* sp. near or = *mali* (Fitch) (3) 31.VII.74, *Hopolothrips fieldsi* Crawford (2) 1.VIII.74, *Liothrips* sp. 1.VIII.74: HOMOPTERA–HEMIPTERA, Aleyrodidae, Aleyrodinae 22.VII.74, 31.VII.74, 1.VIII.74, *Aleurochiton* sp. (?) 3.VII.73; Aphididae, *Amphoraphora* sp. (2) 8.VII.73, *A. sensoriata* Mason 7.VII.73, *Anoecia cornia* (F.) (3) 30.VII.74, *A. querci* (Fitch) 3.VIII.74, (2) 15.VIII.74, *Aphis* sp. 27.VII.73, 1.VIII.74, *A. gossypii* Glov. 27.VIII.74; *A. rubifolii* (Thos.) 29.VII.74, *A. sambucifoliae* Fitch 12.VII.74, *Capitophorus elaeagni* (Del Guer.) 19.VII.74, 22.VII.74, 1.VIII.74, *Chaitophorus* sp. 1.VIII.74; *C. hippophaes* (Wik.) 17.VII.74, 3.VIII.74, *C. pusillus* Hottes and Frison 27.VII.74, Drepanosiphinae 30.VII.73, *Drepanaphis* sp. 25.VII.73, *D. acerifoliae* (Thos.) 29.VII.74, *D. saccharini* Smith and Dillery 6.VIII.74, *Dysaphis* sp. 16.VII.74, *D. radicola* (Mord.) 31.VII.74, *Essigella pini* Wilson 22.VIII.74, *Hyadaphis foeniculi* (Pass.) 1.VIII.74, *Hyalopterus pruni* (Geof.) 15.VIII.74, *Macrosiphon* sp. 30.VI.74, *M. liriodendri* (Monell) (3) 30.VI.74, 12.VII.74, 16.VII.74, 19.VII.74, (2) 30.VII.74, *M. avenae* (F.) 30.VI.74, 16.VII.74, 31.VII.74, 1.VIII.74, *M. euphorbiae* (Thomas) 1.VIII.74, *Mastopoda pteridis* Oestlund 27.VIII.74 *Monellia* sp. 30.VI.74, *M. costalis* (Fitch) 1.VII.73, *Monelliopsis* sp. (2) 19.VII.74, 31.VII.74, 20.VIII.74, *Myzocallis* sp. (2) 1.VIII.74, 15.VIII.74, (2) 23.VIIII.74, *M. asclepiadis* (Monell) (2) 1.VIII.74, 15.VIII.74, (2) 22.VIII.74, 23.VIII.74, *Myzus persicae* (Sulz.) 1.VIII.74, *Masonovia* sp. 7.VIII.74, *Ovatus phyloxae* (Sampson) 12.VII.74, *Prociphilus fraxinifolii* (Riley) 9.VII.74, 15.VII.74, 18.VII.74, 29.VII.74, *Rhopalosiphum* sp. 1.VIII.74, *R. maidis* (Fitch) 16.VII.74, 19.VII.74, 22.VII.74, 30.VII.74, 31.VII.74, 1.VIII.74, *Schizolachnus* sp. 16.VII.73, *Thecabius* sp. 12.VII.74, *Therioaphis trifolii* (Thos.) 15.VII.74, *Tinocallis kahawaluokalani* (Kirk.) 17.VII.74, 19.VII.74, *T. ulmifolii* (Monell) 7.VII.74, 9.VII.74, 12.VII.74, 16.VII.74, 17.VII.74, 19.VII.74, 22.VII.74; Unidentified 30.VI.74, (2) 12.VII.74, (4) 17.VII.74, (2) 18.VII.74, (4) 19.VII.74, 27.VII.74, (2) 29.VII.74, (3) 31.VII.74, (5) 1.VIII.74, 15.VIII.74, 22.VIII.74; Cicadellidae, *Agallia constricta* Van Duzee 16.VII.74, *Alebra albostriella* (Fallen) (2) 22.VII.74, *Aphrodes* sp. 1.VII.73, 7.VII.73, (4) 8.VII.73, 16.VII.73, 10.VII.74, 19.VII.74, *Balclutha* sp. (2) 7.VII.73, *Coelidia olitoria* (Say) 20.VII.74, Deltocephalinae 23.VII.73, *Dikraneura* sp. 7.VII.73, 12.VII.74, 15.VII.74, 18.VII.74, *D. mali* (Provancher) 16.VII.74, 1.VIII.74, *Empoasca* sp. 16.VII.74, 17.VII.74, 20.VII.74, *E. bifurcata* DeLong (2) 25.VII.73, *Erythroneura* sp. 7.VII.73, 8.VII.73, (2) 12.VII.74, 15.VII.74, (3) 16.VII.74, (2) 20.VII.74, 29.VII.74, (2) 31.VII.74, *E. tricincta* Fitch 14.VII.74, *E. vulnerata* Fitch 12.VII.73, *Forcipata loca* DeLong and Cardwell 20.VII.73, 1.VIII.74, *Graminella nigrifrons* (Forbes) (2) 29.VII.73, 14.VII.74, 30.VII.74, 31.VII.74, 1.VIII.74, 3.VIII.74, *Macrosteles fascifrons* (Stål.) 8.VII.73, 10.VII.73, 20.VII.74, 30.VII.74, *M. slossoni* (Van Duzee) 12.VII.73, *Onecpsis verticis* (Say) 30.VII.74, 2.VIII.74, *Scaphytopius* sp. 30.VII.74, *S. acutus* (Say) 31.VII.74, *S. ampius* DeLong and Mohr 3.VIII.74, Typhlocybinae 30.VII.74, 31.VII.74, *Xestocephalus pulicarius* Van Duzee 30.VII.74; *Cixidae* 20.VII.74; Delphacidae, *Delphacodes* sp. 16.VII.73, *D. puella* Van Duzee (2) 27.VII.74, *Pissonotus* sp. 22.VII.74; Derbidae, *Cedusa gedusa* McAtee 29.VII.74; Miridae, *Lygus lineolaris* (P. daB.) 7.VII.73, Unidentified (2) 15.VII.74, (3) 16.VII.74, (3) 29.VII.74, (4) 31.VII.74, (3) 1.VIII.74, (5) 15.VII.74, (4) 23.VIII.74; Phylloxeridae, *Phylloxera* (3) 15.VIII.74, Psyllidae, *Craspedolepta* sp. 16.VII.74, *C. fumida* Caldwell 16.VII.74, *Psylla annulatus* Fitch 1.VIII.73, Unidentified 7.VII.73, 8.VII.73; Tingidae, *Corythucha arcuata* (Say) 29.VII.74, (2) 3.VIII.74, LEPIDOPTERA, Tineidae 31.VII.74, Unidentified (2) 1.VIII.74: DIPTERA, Unidentified 16.VII.74, (2) 30.VII.74, (13) 31.VII.74, (13) 1.VIII.74, (2) 12.VIII.74, 15.VIII.74, (3) 23.VIII.74; Agromyzidae, *Cerodontha dorsalis* (Loew) 29.VII.74, *C.* (*Poemyza*) *muscina* (Meigen) 17.VII.74; Cecidomyiidae, Cecidomyiidi 9.VII.74, 10.VII.74, (2) 12.VII.74, (3) 20.VII.74, 1.VII.74, *Anarete* sp. 29.VII.73, 27.VII.74, 2.VIII.74, 3.VIII.74, (2) 20.VIII.74, *A. pritchardi* Kim 20.VII.73, *Asteromyia* sp. 12.VII.74, *Atrichopogon levis* (Coq.) 20.VII.74, *Contarinia* sp. 19.VII.74, *Culicoides paraensis* (Goeldi) 20.VII.74, 22.VII.74, *Dasineura* sp. 17.VII.74, 22.VII.74, 27.VII.74, (2) 31.VII.74, *Dasyhelea* sp. 22.VII.74, 30.VII.74, 31.VII.74, 3.VIII.74, *Forcipomyia* sp. 30.VI.74, *F. brevipennis* (Macq.) 30.VI.74, *Hyperdiplosis* sp. 15.VII.74, *Lasioptera* sp. (2) 16.VII.74, *Lestremia* sp. (3) 10.VII.73, 28.VII.73, *Lestodiplosis* sp. 12.VII.74, *Micromyia* sp. 9.VII.73, 15.VII.73, 18.VII.73, 25.VII.73, (2) 17.VII.74, *Neolosioptera* 7.VII.73, 12.VII.74, 19.VII.74, *Procystiphora* sp. 30.VI.74, 7.VII.74, 19.VII.74, *Porricondyla* sp. 19.VII.74, 31.VII.74, *Resseliella* sp. 30.VII.73, (2) 16.VII.74, (2) 17.VII.74, 22.VII.74, 3.VIII.74; Chaoboridae, Unidentified (3) 7.VII.73, *Chaoborus* sp. (2) 30.VI.74; Chironomidae, Orthocladiinae (3) 1.VII.73, 30.VII.74, (2) 7.VII.74, (3) 12.VII.74, (4) 15.VII.74, 18.VII.74, (2) 19.VII.74, 20.VII.74, (3) 22.VII.74, (5) 31.VII.74, 2.VIII.74, 6.VIII.74 (3) 15.VIII.74, (2) 23.VIII.74, *Anatopynia* sp. 22.VII.74, *A. dyari* (Coq.) 10.VII.73, *Chironomus* sp. 12.VII.74, 17.VII.74, 20.VII.74, *Cricotopus* sp. (2) 20.VII.73, 25.VII.73, (2) 26.VII.73, (2) 16.VII.74, 22.VII.74, *Procladius bellus* (Lw.) 16.VII.74, *P. culiciformis* (L.) 18.VII.73, *Tanytarsus* sp. 30.VII.74; Chloropidae, *Conioscinella* sp. 16.VII.74, *Elachiptera umbrosa* (Lw.) 7.VII.73, *Goniopsita catalpae* (Mall.) 1.VIII.74, *Oscinella carbonaria* (Lw.) 25.VII.73, 29.VII.73, (2) 31.VII.74, *O. painteri* Sabr. 28.VII.73, *Siphonella nigripalpis* (Mall.) 30.VII.74, *Thaumatomyia bistriata* (Wlk.) 2.VIII.74, *T. glabra* (Mg.) 31.VII.74; Dolichopodidae, *Chrysotus* sp. (5) 1.VII.73, 7.VII.74, 12.VII.74, 18.VII.74, *Gymnopternus debilis* Loew 17.VII.73, *Thrypticus* sp. 7.VII.73, Drosophilidae, *Scaptomyza adusta* (Lw.) 12.VII.74, *S. pallida* (Zett.) (5) 7.VII.73, 15.VII.74, 18.VII.74, 20.VII.74, 30.VII.74, 6.VIII.74, *S. wheeleri* Hackmann 30.VII.74; Lonchopteridae, *Lonchoptera furcata* (Fallen) 1.VIII.74; Phoridae, Unidentified (2) 16.VII.73, (2) 15.VII.73, *Megaselia* sp. (3) 7.VII.73, 7.VII.74, 12.VII.74, 15.VII.74, (3) 16.VII.74, (4) 17.VII.74, (3) 31.VII.74, *Puliciphora* sp. (6) 16.VII.74, (2) 17.VII.74, (4) 22.VII.74, (2) 12.VIII.74; Psychodidae, Unidentified 28.VII.73; *Psychoda* sp. (2) 1.VIII.74; Scatopsidae, Unidentified 8.VII.73, *Scatopse fuscipes* Mq. 31.VII.74, *Rhegmoclema* sp. 31.VII.74, 6.VIII.74, 18.VII.74; Sciaridae, *Bradysia* sp. (3) 1.VII.73, (4) 12.VII.74, (2) 15.VII.74, (4) 16.VII.74, (2) 20.VII.74; Sepsidae, *Sepsis punctum* (Fab.) 12.VII.74; Sphaeroceridae, *Leptocera* sp. (5) 16.VII.73, (2) 22.VII.73, 20.VII.74, (2) 30.VII.74, 31.VII.74, *L.* (*Pterogramma*) *palliceps* Johnson 16.VII.74, *Sphaerocera pusilla* (Fallen) 7.VII.73, *S. vaporarium* Holaday 31.VII.74, 1.VIII.74; Stratiomyidae, *Microchrysa polita* (L.) (2) 31.VII.74, 1.VIII.74, *Oxycera* sp. 15.VIII.74, Tipulidae, 16.VII.74: COLEOPTERA, Unidentified 30.VI.74, (2) 12.VII.74, 22.VII.74, (3) 31.VII.74, Alleculidae, *Mycetochara haldemani*: LeC. 2.VIII.74, Chrysomelidae, *Baliosus* sp., 12.VII.74, 16.VII.74; 20.VII.74, 25.VII.74, *Chaetocnema* sp. 25.VII.73, 30.VII.74, (2) 31.VII.74, (2) 1.VIII.74, 11.VIII.74, 14.VIII.74, 25.VIII.74; Curculionidae, *Gymnetron pascuorum* (Gyll.) 16.VII.73, 17.VII.74, 19.VII.74, *Microtrogus picirostris* (F.) (3) 17.VII.74, *Pseudopentarthrum* sp. 25.VII.73, I.VIII.73; Hydrophilidae, *Cercyon* sp. 25.VIII.74, 27.VIII.74; Lathrididae, *Corticaria* sp. 27.VIII.74; Leptodiridae, *Nemadus* sp. prob. *parasitus* LeC. 22.VIII.74; Leiodidae, *Colenis impunctata* LeC. 28.VIII.74; Mycetophagidae, *Litargus quadrispilotus* LeC. 31.VII.74, *L. nebulosus* LeC. 31.VII.74; Phalacridae, *Stilbus* sp. (2) 31.VII.74 (2) 1.VIII.74, 2.VIII.74, *Olibrus* sp. 28.VII.74; Ptilodactylidae, *Ptilodactyla angustata* (3) 16.VII.73; Rhipiphoridae, *Rhipiphorus* sp. 18.VII.74, *Hypothenemus* sp. (3) 9.VII.74, *Pityophthorus* sp. 7.VII.73, *Pityogenes hopkinsis* Swaine 20.VII.74; Staphylinidae, Unidentified, (2) 15.VII.74, (5) 16.VII.

74, 22.VIII.74, 23.VIII.74: STREPSIPTERA, Stylopidae, *Pseudoxenos lugubris* (Pierce) 18.VII.74, Unidentified 31.VII.74: HYMENOPTERA, Unidentified (2) 16.VII.74, 19.VII.74, (3) 31.VII.74, Aphelinidae, Unidentified 27.VII.74, 1.VIII.74; Aphidiidae, *Aphidius* sp. 18.VII.74, *Lysiphlebus* sp. 30.VII.74; Brachonidae, *Asobara* sp. 16.VII.74, 19.VII.74, 30.VII.74, *Aspilota* sp. 20.VII.74, 31.VII.74, *Chorebus* sp. 2.VIII.73, *Oenonogaster* sp. 12.VIII.73, *Synaldis* sp. 20.VII.74, 31.VII.74; Ceraphronidae, *Ceraphron* sp. (4) 17.VII.74, *Conostigmus* sp. (2) 31.VII.74, *Lygocerus* sp. 12.VII.74, (2) 16.VII.74, 30.VII.74; Chalcedectidae, *Euchrysia* sp. 25.VII.73; Cynipidae, Encoilinae 16.VIII.74, *Alloxysta* sp. 3.VIII.74; Dryinidae, Unidentified 31.VII.74, 1.VIII.74, Encyrtidae, new *Encydnus* sp. 10.VII.74, 12.VII.74, 16.VII.74, 19.VII.74, 31.VII.74, 1.VIII.74; Eulophidae, Unidentified 31.VII.74; Eurytomidae, Unidentified 16.VII.74; Formicidae, *Dolichoderus* sp. 16.VII.74, *Lasius* sp. (10) 26.VII.73, (2) 22.VII.74, (3) 27.VII.74, 15.VIII.74, *Leptothorax* sp. (3) 28.VII.74, *Monomorium minimum* (Buckley) 30.VI.74, *Paratrechina* sp. 26.VII.73, 19.VII.74, *Ponera pennsylvanica* Buckley 31.VIII.74, (4) 1.VIII.74, (5) 23.VIII.74, (3) 27.VIII.74, *Solenopsis molesta* (Say) 1.VIII.74; Mymaridae, Unidentified 12.VII.74, 16.VII.74; Pteromalidae, Pteromalini 16.VII.74, 19.VII.74, (2) 31.VII.74.

Enemies.—Cerotainia albipilosa are sometimes preyed on by arthropods larger than themselves. Thirteen instances of predation were observed: *Theridon* sp. (Tetragnathidae: Araneida), *Vespula* sp. (2) and *V. arenaria* (F.) (8) (Vespidae: Hymenoptera), *Efferia aestuans* (L.) and *Dioctria tibialis* McAtee (Asilidae: Diptera). Several unsuccessful attacks were directed by the following: *Pisaurina mira* (*Walkenuer*) (Pisauridae: Araneida), *Misunera* sp. (Thomopsidae: Araneida), *Laphria sicula* McAtee, *D. tibialis* (Asilidae: Diptera), and *Vespula* spp. Each predator used a specific attack strategy. *Vespula* spp. flew along the margin of the study site and hovered frequently in front of occupied perches. This behavior "flushed" the asilid which was attacked as it attempted to escape. *Vespula* spp. sometimes attacked before the asilid attempted to fly away. *Theridon* sp. captured its prey with a web while the other araneids attacked from a concealed position below a foraging site. The asilid predators, which were usually perched near the prey, attacked *C. albipilosa* when it flew from a perch. While cannibalism by this species was not observed, males and females displayed agonistic behavior toward other males (Scarbrough and Norden, 1977).

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Associate Professor of Biology, Department of Biology, Towson State University, Baltimore, Maryland 21204.

Footnote

[1] Portions of this work were supported by funds obtained from the Towson State University Faculty Research Committee.

NOTE

OXAEA AUSTERA GERSTAECKER IN BOLIVIA, WITH A NEW HOST RECORD (HYMENOPTERA: APOIDEA)

Oxaea austera Gerstaecker is a rather little known South American bee that has been reported from a few collections made in northeastern and southern Brazil (Ceará, Maranhão, São Paulo, and Rio Grande do Sul), Paraguay and Mesopotamian Argentina (Ducke, 1910, Revue d'Entomol. (Caen), 28:82). Hurd and Linsley (1976, Smiths. Contrib. Zool., 220) have recently summarized the few available records of floral hosts for the species. The purposes of this paper are to report the genus *Oxaea* and *O. austera* from Bolivia for the first time, to add a floral host to those already known for *O. austera*, and to report oxaeids for the first time as visitors of Passifloraceae.

On 6 December 1973, I collected four males of *Oxaea austera* from blossoms of a trailing *Passiflora* sp. (Passifloraceae) growing along the roadside seven kilometers south of Warnes (ca. 17°30′S, 63°10′W, 375 m) in the Department of Santa Cruz, Bolivia. There, these robust bees (ca. 2 cm) approached the flowers very rapidly and then braked to hover stationarily in front of the blossoms before landing and entering them. This same behavior in males of *O. austera* was noted by Schrottky (1904, Allgemeine Zeitschr. Entomol. 9:346) at flowers of an exotic in Brazil, the motherwort, *Leonurus sibiricus* L. (Lamiaceae). This plant is the only previously known nectar source for males of *O. austera*.

The bees that I took from the *Passiflora* near Warnes were peppered with pollen and particularly so on their thoracic dorsa. It seems probable that these large bees are effective pollinators of at least this species of *Passiflora*. No *Oxaea* species has previously been recorded from *Passiflora* (see Hurd and Linsley, *supra cit.*, for a comprehensive summarization of the available floral records), and the genus is generally thought to be pollinated by carpenter bees (*Xylocopa* sp.) (Faegri and van der Pijl. 1971. The Principles of Pollination Ecology, ed. 2, Pergamon).

Thanks are due to Prof. J. S. Moure of the Universidade Federal do Paraná, Curitiba, Brazil, for his determinations of the bees and to Prof. Richard B. Selander of the University of Illinois, Urbana, for his support of the author's fieldwork in Bolivia. The specimens of *Oxaea austera* reported herein will be deposited in the collection of the Section of Faunistic Surveys and Insect Identification of the Illinois Natural History Survey at Urbana.

John K. Bouseman, *Agricultural Entomology, Illinois Agricultural Experiment Station and Section of Economic Entomology, Illinois Natural History Survey, Urbana, Illinois 61801.*

NOTE

HUMAN ORAL MYIASIS IN VIRGINIA CAUSED BY *GASTEROPHILUS INTESTINALIS* (DIPTERA: GASTEROPHILIDAE)

The horse bot fly, *Gasterophilus intestinalis* (L.) is a widespread species causing enteric myiasis in equines. Subcutaneous myiasis due to gasterophilids, often broadly termed "creeping eruption" or "larval migrans," has been reported involving people associated with horses. In these instances 1st-instar larvae burrow into the skin and produce tunnels which are accompanied frequently by an intense itching sensation. Infestations may end spontaneously or by suppuration (James. 1947. USDA Misc. Publ. 631:92–99). Zumpt (1965. Myiasis in man and animals in the Old World. Butterworths, London. 267 pp.) states that these misplaced larvae never reach the second stage.

Creeping eruption in man tends to occur on the extremities (Austmann. 1926. J. Amer. Med. Assoc. 87:1196–1200). Chereshnev (1953. Dokl. Akad. Nauk (N.S.). 91:173–176) found that rubbing or moistening of *G. intestinalis* eggs is necessary to stimulate hatching. He reported that 1st-instar larvae could penetrate the mucous membrane, but not human skin. However, Danilov (1973. Med. Parazitol. Parazit. Bolezn. 42:361) described multilinear human myiasis with puritis and skin vesicles on the extremities and stomach caused by 65 *G. equi* (= *intestinalis*) larvae.

James J. Keeble, Entomologist, Maintenance Division, Atlantic Division, Naval Facilities Engineering Command, Norfolk, provided the following information from a case of human myiasis in Virginia. On 22 December 1976 a 10-year-old Virginia Beach girl complained of an irritation in her mouth. Subsequently, a physician removed a small *G. intestinalis* larva from the inner lining of her mouth near the jaw. Further examination of the oral area and tongue revealed no other larvae.

The girl received a horse as a present two months before the infestation was noticed. She was with the horse regularly and kissed it frequently. It is not known if the infestation was a direct result of oral contact or if the larva was transferred to the mouth indirectly. The former route seems likely.

Sukhapesna et al. (1975. J. Med. Entomol. 12:391–392) reported that *G. intestinalis* eggs deposited in late fall in Kentucky may remain viable for several months. Hatch of field-collected eggs terminated in late January. They stated that egg age and environmental temperatures probably influenced egg viability.

Causey (1937. J. Econ. Entomol. 30:39–40) noted that the presence of animal myiasis in livestock poses potential public health problems for humans. While such cases may produce relatively mild discomfort, they demonstrate that care should be exercised by persons in close contact with domestic livestock or pets. A variety of parasites may be encountered under similar circumstances, several of which are not so benign.

Dr. R. J. Gagné, Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, confirmed identification of the specimen.

L. H. Townsend, Jr., R. D. Hall *(Graduate Research Assistants) and* E. C. Turner, Jr. *(Professor), Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.*

NOTE

CYLINDROCNEMA PLANA MAYR, 1865, A SENIOR SYNONYM OF *NOPALIS CRASSICORNIS* (REED), 1898 (HEMIPTERA: ACANTHOSOMATIDAE)

The Heteroptera that formed the basis of Edwyn C. Reed's "Sinopsis de los Hemipteros de Chile, Primera Parte: Heteropteros" was purchased by Carl J. Drake who bequeathed his collection, including Reed's specimens, to the United States National Museum where it is now housed. All specimens from the Reed collection bear a printed label "Sin. Hem. Chile Coll., E. C. Reed" but, unfortunately, very few bear a locality label; some of the specimen-pins bear Reed's handwritten identification labels. Among the latter specimens is one labeled "L. crassicornis N. S. ♀." Even though this specimen has no locality label it is hereby designated the lectotype of *Lanopis crassicornis* Reed. The other specimen of the two that comprised the type-series is missing; both specimens were reported in Reed's original description (1898. Rev. Chileña de Hist. Nat. 2:156–157) as being from the island of Chiloe.

Reed's specimen agrees very well with the original description of *Cylindrocnema plana* Mayr (1865. Verh. Zool.-Bot. Ges. Wien. 14:912–913), and especially in such critical characters as two-segmented tarsi; large size [15 mm here, 12 mm in Mayr's description]; thickened antennal segments, especially the second and third; angularly produced humeral angles concave along the posterior margin; hemelytral membrane narrowly produced along costal margin [to a point about opposite midlength of corio-membranal suture]; prosternum with a deep mediolongitudinal groove [as wide as labial segment I]; and venter of abdomen mediobasally convex but without anteriorly projecting tubercle or spine. Comparison of Reed's specimen with specimens labeled as *C. plana* revealed no taxonomic differences and showed that both species share the lack of a foliaceous carina on the mesosternum.

Although Reed listed *C. plana* for Chile, apparently on Mayr's original data, he did not include that genus in his key to the genera of "Ditomotarsina" and perhaps thus misled himself into assigning this specimen to *Nopalis* where it did not agree with any of the other species.

I conclude *Nopalis crassicornis* (Reed), 1898, is a junior synonym of *Cylindrocnema plana* Mayr, 1865, and so assign it here as NEW SYNONYMY.

R. C. Froeschner, *Department of Entomology, U.S. National Museum, Washington, D.C. 20560.*

NOTE

THE STINK BUG *PADAEUS TRIVITTATUS* STÅL AND NOT *PADAEUS VIDUUS* (VOLLENHOVEN) IN THE UNITED STATES (HETEROPTERA: PENTATOMIDAE)

This tropical American species was first reported for the United States from "Florida" under the preoccupied name *Padaeus irroratus* (Herrich-Schaeffer) by Van Duzee (1904. Trans. Amer. Ent. Soc., 30:78); he credited the record to a specimen in the H. G. Barber collection. Barber (1910. Jour. N.Y. Ent. Soc., 18:35), using the same name combination, corrected the locality in Van Duzee's report and gave the specimen data as "Huachuca Mts., Ariz., 1899, collector R. E. Kunze." Later, Van Duzee (1917. Univ. Calif. Pubs. Ent., 2:44) catalogued it from "Ariz. (not Fla.)." All subsequent listings of this species for the United States appear to be based on these references.

Barber's now headless specimen, still bearing the Van Duzee determination label as *Padaeus irroratus*, is in the National Museum of Natural History. Examination found it to represent another tropical American species, *P. trivittatus* Stål, and not *P. viduus*. Thus the latter name must be deleted from the United States list and, assuming the locality is correct, the former name must be added.

These two species can be separated readily by any of several characters; three easily used color characters are compared in the following couplet:

Abdomen dark brown to black with numerous widely scattered yellow flecks. Costal margin (except at very base) concolorous with the brown to black corium. Black color of connexivum broadly reaching extreme lateral margins of segments and more or less enclosing a small, median, suboval pale spot *P. viduus* (Vollenhoven)

Abdomen yellow with three longitudinal black stripes, one median and one each side sublaterally. Costal margin along basal third narrowly calloused yellow. Black color of connexivum separated (often narrowly) from lateral margins of segments for full length *P. trivittatus* Stål

Richard C. Froeschner, *Department of Entomology, U.S. National Museum, Washington, D.C. 20560.*

BOOK REVIEW

Mechanical Design in Organisms, by S. A. Wainwright, W. D. Biggs, J. D. Currey, and J. M. Gosline. John Wiley and Sons, New York. 423 pp. Cost $19.50.

This book will be of interest to functional morphologists, some physiologists, and some ecologists.

Mechanical Design in Organisms is somewhat revolutionary in that it departs from the traditional concept of rigid discipline orientation and attempts to integrate principles of mechanical engineering with biological structure and function. An implicit assumption throughout the book is that if one understands the physical basis of a phenomenon, general principles can be used to predict responses to different conditions. In this sense the text serves as a valuable companion to Alexander's (1968) *Animal Mechanics* and to his (1971) *Size and Shape*.

The text is divided into three parts ("materials," "structural elements and systems," and "ecomechanics") covering eight chapters. Authorship appears evenly divided with each writer contributing at least one chapter, and some chapters are co-authored.

"Materials" constitutes half the text and provides essential physical parameters and their mathematical derivation. This section has a moderate mathematical basis, which is to be expected considering the nature of the subject matter. However, the approach taken by the authors in developing the mathematical relationships is methodical and should not prove an insurmountable obstacle to understanding. Types of biological materials including tensile materials (chitin, cellulose, and collagen), pliant materials (resilin, elastin, and cartilage), and rigid materials (keratin, bone, etc.) are discussed.

"Structural elements and systems" is concerned primarily with the behavior of materials under conditions of stress and formulates principles of structural optimization. Chapter 7 considers mechanical support in organisms and develops principles for biological structural systems.

"Ecomechanics" is the shortest part of the book (one chapter) and is largely conjectural. Ecology and mechanical design are interrelated, but the extent of interrelationship is unknown. Among the environmental factors that influence mechanical design are gravity, surface tension, fluid flow, and pressure. Wainwright attempts to develop ecological predictions based on these biomechanical data. However, much more data must be accumulated before the interaction of environmental parameters and biological structure is appreciated.

The only limitation that I can find with the book is that it lacks any treatment of fluid mechanics. However, the omission is acknowledged by the authors and is not significant in view of the enormous literature developed by engineers. The authors do not emphasize insects in their development of theories about mechanical design. Were they to do so, the general principles that they seek to develop would be circumscribed.

I found the book lively and well written. The organization is good, ideas are presented concisely, and the innumerable line drawings, graphs, and figures clarify the points made in the text. *Mechanical Design in Organisms* should stand for some time as a fundamental reference in the field of biomechanics.

Gordan Gordh, *Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., c/o U.S. National Museum, Washington, D.C. 20560.* (Present address: *Department of Entomology, University of California, Riverside, California 92521.*)

BOOK REVIEW

Controlling Fruit Flies by the Sterile-Insect Technique. 1975. IAEA, Vienna, Austria, STI/PUB/392. 175 pp. Available from Unipub. Inc., P.O. Box 433, Murray Hill Station, New York, N.Y. 10016. Price $10.00.

The following words, appearing as part of the foreword to this very interesting book, comprise a statement which can well stand alone to serve as the *raison d'etre* for the volume: ". . . the containment of fruit flies by methods less reliant on insecticides has taken on a new urgency . . . . The Mediterranean fruit fly, which first appeared in the 1950's in Central America, has surged northward throughout this area and is now poised to invade Mexico. The economic significance of an unchecked spread of this pest is reflected in an estimated annual loss of $6.8 million for the Central American area excluding British Honduras and Mexico. Should the medfly invade those two countries, their citrus industries would suffer a combined loss of $6 million. Should the medfly go unchecked and invade the United States, the U.S. fruit industry would lose annually about $85 million for citrus and $200 million for deciduous fruits . . . ."

A result of a panel and research coordination meeting organized by the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, this collection of authoritative papers addresses a wide range of activities within the sterile-male technique picture. Not only is mass-rearing (the heart of the matter) discussed thoroughly, but subjects such as genetic variation, comparative behavior, and field observations are also included for the most important of the world's tephritids. Summaries of work performed at various institutions throughout the world are included, as are concluding statements and general recommendations for work to be undertaken in the future.

The authors of the eleven major papers in the volume are widely known in and outside their respective specialties, a feature adding materially to the excitement inherent in the messages they deliver. It is gratifying to realize that these scientists are able to contribute so much substantive material to the general subject and at the same time deal effectively with the specifics so valuable to the individual researcher in the laboratory or in the field. It is hoped that the International Atomic Energy Agency will be able to keep this valuable series alive in light of the severe economic implications presented by the singular habits of these important insects.

Richard H. Foote, *Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., c/o U.S. National Museum, Washington, D.C. 20560.*

BOOK REVIEW

The Windows to His World. The Story of Trevor Kincaid. By Muriel L. Guberlet. 1975. 287 pp., 16 photographs. Pacific Books, Publisher, P.O. Box 558, Palo Alto, California 94302. $9.95.

The name of Trevor Kincaid (1872–1970) is little known by the current generation of American entomologists unless it be in the Northwest where he worked at the University of Washington as a student, professor, and emeritus professor of zoology for about 75 years. This book is a fascinating biography of a most unusual man whose inspired teaching and whose widely recognized versatility in most branches of natural history made him almost a legend to several generations of students. From early middle age on, he was chiefly concerned with the marine life of the Puget Sound area, especially the oyster and fisheries industries. Thus he established the Puget Sound Biological Station, which became the University of Washington Oceanographic Laboratories. Nevertheless, throughout his life, but especially as a boy in Ontario and in Washington (after he moved there in 1889) and as a student and youthful professor at the University, he collected and studied insects with boundless enthusiasm. This biography reports (page 45) that during 1890–94 he made a personal collection of 60,000 insects and also sent 100,000 specimens to entomologists in all parts of the U.S. Two expeditions to Alaska were of much importance in his early career. In 1897 he participated in a 3-month study of the fur seals of the Pribilof Islands, in the company of David Starr Jordan and a group of Stanford University students including R. E. Snodgrass. Then in 1899 he went on the Harriman Alaska Expedition during which he collected 1,000 species of insects. As a result of these collections, he spent the summer of 1900 in Washington, D.C. and worked on Alaskan insect specimens. Numerous animals (including 51 insects) have been named in his honor. For short periods of 1908 and 1909 (in the book wrongly stated as 1906 and 1907), he traveled and collected widely in Japan and Russia, respectively, as a special agent of the U.S. Department of Agriculture in search of parasites of the gypsy moth. At the National Archives I have examined a thick folder of interesting correspondence relating to the Japanese trip. Letters are chiefly between Kincaid and L. O. Howard, but also included are some letters with State officials in Massachusetts and others. Thus Trevor Kincaid's contributions to entomology and to biology generally are much greater than suggested by his modest though significant bibliography of papers. In fact, his interests were so broad that he thought of himself as an "omnologist."

This book is well indexed and illustrated and is fine reading for people interested in biography, the history of science, or the growth of higher education in the Northwest. Mrs. Guberlet is the widow of a former university zoologist, Prof. John Guberlet who taught in Prof. Kincaid's department for 17 years, so she had a long acquaintance with Kincaid. She also had available an extensive but unpublished autobiography. Her book is a beautifully writen and warmly personalized testimony to Kincaid's splendid human qualities and constant dedication to his science, his family, and his friends. Those of us who never met him are given a glimpse of a man not easily forgotten.

Ashley B. Gurney, *Resident Cooperating Scientist, Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.*

BOOK REVIEW

Theodore D. A. Cockerell. Letters from West Cliff, Colorado. 1887–1889. 1976. William A. Weber (Ed.) 222 pp., illus. Colorado Associated University Press, 1424 15th St., Boulder, Colo. 80309. $8.95.

Theodore Dru Alison Cockerell (1866–1948) was a very unusual and productive man. The letters in this book, selected from a large accumulation sent back to England during the nearly 3-year period of his first visit in America, are of great interest both for what they reveal of Cockerell's youth and as descriptive accounts of life in a part of Colorado about 90 years ago. A scion of a substantial English family, since then distinguished by several outstanding members, "Theo" went to West Cliff (now Westcliffe), in Wet Mountain Valley about 50 miles west of Pueblo, just prior to his 21st birthday and lived in a rural community in which English families were well represented. Many had gone there for health reasons, as he did to counter frailness and suspected tuberculosis. The letters are addressed chiefly to Annie Fenn, whom he married in 1891, or to her brother. In England he had already begun a lifestyle different from that of most boys: he was not involved in athletics, regarded many of their activities as frivolous, and, partly due to his poor health, omitted much formal schooling. Instead, he was a somewhat delicate, odd, naturalist type, and by the time he was 20 he had published 158 notes and papers on snails, insects, plants and other subjects; his pattern of short, quickly written contributions had been established. While quite young he had become familiar, at the British Museum, with identification practices and, when unable to recognize the species of local plants and animals from available handbooks, he entertained himself by writing short descriptions and inventing scientific names for them.

At West Cliff he lived mainly with a congenial neighborhood family and supported himself by doing light farm chores, informal teaching, sketching and many other tasks for which his background qualified him. He regularly received several natural history periodicals from England and the U.S., and he corresponded actively with established workers (Alfred R. Wallace, for whom he later worked in England; Binney and Pilsbry, among malacologists; Riley, Scudder, Strecker, Wickham and other entomologists). He referred (page 163) to a paper by Scudder on fossils from Florissant, which is only 60 miles from Westcliffe, but evidently did not go there to collect seriously until 1906. In 1907 one of his students, S. A. Rohwer, found a remarkably well preserved specimen of a strange neuropteron with long narrow hind wings, one of the family Nemopteridae, which does not now occur in North America. A picture of the fossil specimen was shown on covers of *Entomological News* in 1908, and the species was mentioned in a *News* editorial as "the most remarkable insect made known during the preceding year."

The numerous Cockerell letters, which have been chosen and grouped by subjects likely to interest a variety of readers, are illustrated by many of the simple sketches that originally accompanied them. The editor, Dr. W. A. Weber, a Colorado botanist, prepared the book with great care. In 1965 he published a short biography and a bibliography of 3,904 Cockerell publications (Univ. Colo. Studies, Series in Bibliography No. 1:1–124), and he also listed about 30 biographical articles and notices about Cockerell (customarily pronounced with emphasis on the first syllable). The bibliography is an invaluable reference to the numerous papers on bees, coccids, fossils, and other subjects reported on by Cockerell.

Ashley B. Gurney, *Resident Cooperating Scientist, Systematic Entomology Laboratory, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.*

BOOK REVIEW

A Revision of Western Nearctic Species of Torymus *Dalman (Hymenoptera: Torymidae).* E. E. Grissell. 1976. Univ. Calif. Publ. Entomol. 79:1–120, 109 figs., 6 pls. Cost $6.00.

The Chalcidoidea presently consist of about 1,200 genera and 10,000 described species distributed over 18 families. Aside from their small to minute size, the primary limiting factor to studying chalcidoids is a lack of keys to the genera and species. Thus it is with some enthusiasm that I note the publication of a taxonomic study of western species of *Torymus.*

About 25 genera and 180 species of Torymidae have been described in North America; about 100 species have been described in *Torymus.* The genus is poorly studied biologically, but most species for which the biology is known are primary, external parasites of gall-forming insects. Host specificity does not appear to be common in *Torymus* because several well-known species have extensive host lists. The genus appears to be habitat specific.

L. L. Huber (1927. Proc. U.S. Nat. Mus. 70(14):1–114) prepared the last taxonomic study of North American *Torymus.* For many reasons that work is unsuitable. During the fifty years since Huber's study there have been no published taxonomic studies of the North American *Torymus,* and most biological accounts have been anecdotal.

Grissell's study considers 61 species of *Torymus.* He places 17 species in synonymy and described seven new species. I suspect that more new species will be found in the area under consideration. One of the features about the study that I find encouraging is the use of species groups instead of subgenera. Grissell recognizes five species groups in western *Torymus.* When the rest of the New World species are studied, the concepts of these groups will undoubtedly be altered somewhat, but this will not affect the nomenclature of *Torymus.* In general I find this work to be excellent. Characters have been carefully thought out, the keys are workable, descriptions are concise, and extensive distribution and host data are provided. If Grissell extends his studies to *Torymus* found in eastern North America, we will better understand this large and interesting genus.

G. Gordh, *Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.* (Present address: *Department of Entomology, University of California, Riverside, California 92521.*)

BOOK REVIEW

The Tachydromiinae (Diptera: Empididae) of Fennoscandia and Denmark. Vol. 3, Fauna Entomologica Scandinavica. M. Chvála. 1975. Scandinavian Science Press Ltd., Klampenborg, Denmark. 336 pp. Paperback, 98 Dkr. (= $16.00 at this writing). Subscription price: 68.60 Dkr. (= $11.00).

As the needs for reliable identifications increase and as it becomes more and more obvious that the limited number of taxonomists cannot supply all these needs, it is increasingly important that high-quality regional handbooks are produced. Dr. Chvála's study of Tachydromiinae is one of the finest examples of this kind of publication.

"The Tachydromiinae" is the first of a projected group of six volumes on Empididae by Dr. Chvála for this new faunistic series. Altogether, 128 species and 9 genera of Danish and Fennoscandian tachydromiines are treated, and other species that may occur in this area are included in the keys and are briefly diagnosed. The life history and zoogeography of the Tachydromiinae are briefly treated. A succinct but useful description of the adult morphology prepares the non-specialist for using the keys, and a valuable discussion of the classification and phylogeny is included. The author adds a sufficiently detailed section on the material (18,000 specimens) used in the study.

Although only three Holarctic species of Tachydromiinae are known (*Platypalpus unguiculatus* Zett., *Tachypeza winthemi* Zett., and *Drapetis assimilis* Fall.), additional species probably will be found to be Holarctic in the future, and the volume will be especially useful to North American workers in that regard. It should be noted that *Stilpon* (p. 292) is masculine. Also, *Chersodromia difficilis* Lundbeck, 1910 is a junior synonym of *Tachypeza alata* Walker, 1835 (July: not 1836), a validly described species, although originally described as a variety.

This volume is nicely produced, a crisp photo-offset, and the unadjusted right-hand margins are not particularly unpleasing but presumably saved production costs. A special feature is the number and quality of the illustrations: 790 very clear and useful figures.

The following comments, modified from an advertisement by the publisher, gives some detail on the *Fauna Entomologica Scandinavica* series. The series was founded in 1973 and is edited by a committee appointed by five entomological societies in Denmark, Finland, Norway, and Sweden. Four volumes have been published, and over 60 volumes are in preparation. The series presents comprehensive monographic treatments of the fauna of insects and other terrestrial arthropods occurring in northern Europe (Denmark, Finland, Norway, Sweden and adjacent areas).

Each volume deals with a systematic unit, usually a superfamily, family or subfamily. The text includes general chapters on morphology, biology, economic importance, zoogeography and phylogeny. The treatment at the generic and specific levels includes keys and short descriptions, and information on local faunistics, total distribution, habitats, and biology is given under each species.

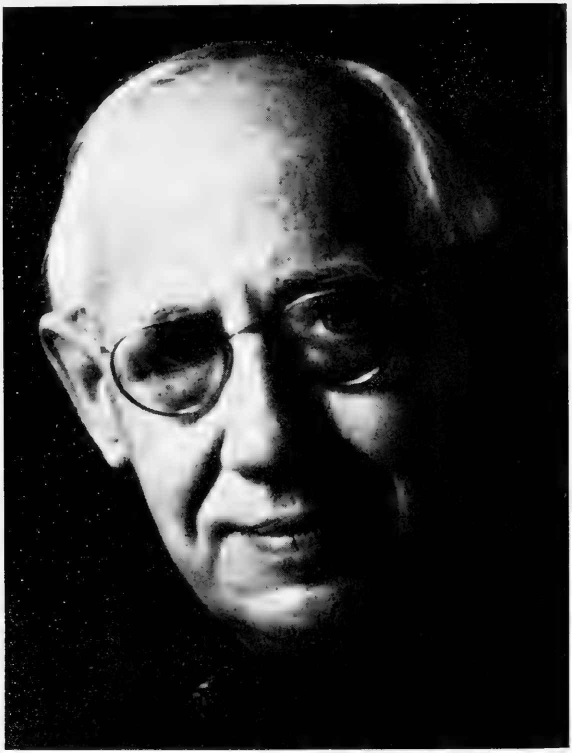
All volumes are richly illustrated, usually with several figures per species. The illustrations include habitus drawings, details of external morphology, complete sets of genitalia drawings, and photos of wings and biological features. The section on Lepidoptera will include color-plates illustrating all species.

Each volume is concluded by a catalogue giving detailed information on the distribution of all species in the area from Great Britain and northern Germany to the North Cape and eastern Karelia.

All volumes will be published in English. It is planned to publish 2–5 volumes with a maximum of 600 pages each year to keep prices at an acceptable level. The volumes will appear at irregular intervals. Volumes appearing in the near future will include the Agromyzidae (Diptera) and Elachistidae (Lepidoptera).

L. Knutson, *Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.*

OBITUARY



The Rev. Thomas Borgmeier, O.F.M.
1892–1975

Thomas Borgmeier was born in Bielefeld, Westphalia, Germany on 31 October 1892 and died in Rio de Janeiro, Brazil on 11 May 1975. In the more than 82 years between these dates Father Borgmeier lived a full life devoted to religious activities, editorial and publishing work, and entomology. Members of the Entomological Society of Washington have many reasons to pause and pay tribute to this great man and distinguished entomologist.

After graduation with distinction in the program of classics and humanities in the "gymnasium" in Bielefeld, Thomas went to Brazil in 1910 to join the Franciscan Order of Friars Minor in January 1911. He studied philosophy in Curitiba from 1912–1914 and theology in Petropolis from 1915–1918. While a student in Petropolis, Brother Thomas became interested in entomology while observing the habits of ants. Spending his vacations in Blumenau, Santa Catarina, in 1917 he met and befriended Professor Hermann von Jhering who had founded the Museu Paulista in São Paulo. Through the generosity of a wealthy industrialist in Rio, Thomas was able to acquire von Jhering's large reprint library on ants as well as a fine binocular microscope. While studying ants in Petropolis, Thomas discovered phorid flies attacking and parasitizing them. Puzzled, he contacted another young entomologist, the Jesuit Father Hermann Schmitz, who as a disciple of the famous E. Wassmann, was well qualified to introduce him to the intricacies of the taxonomy and biology of the Phoridae. Borgmeier's first scientific publication, on the biology of the ant *Odontomachus affinis* Guérin, appeared in 1920, and in 1922 he described his first new species, the phorid *Dohrniphora brasiliensis*.

Father Thomas was ordained a priest in May 1918, and from 1920–1924 was Professor of Biblical Sciences at the Major Seminary in Petropolis. At the same time he contributed freely to the monthly cultural magazine "Vozes de Petropolis" which was published by the friars. He quickly mastered the Portuguese language and translated a number of religious classics into that language. In 1922 Borgmeier began a friendship with Dr. Arthur Neiva who obtained from the Franciscans his complete freedom for entomology and his entrance into public service. In 1923 Thomas became an adjunct research scientist in the National Museum in Rio de Janeiro and in 1924 he moved definitively to the Museum. In 1927 he obtained his Brazilian citizenship and in 1928 went to São Paulo as assistant in entomology under Neiva in the newly founded Instituto Biologico. In 1933 he returned to Rio to become head of the entomological section of the Instituto de Biologia Vegetal in the Botanical Garden, where he remained for eight years.

In 1931 Father Borgmeier founded the international journal, Revista de Entomologia, which he edited and published until 1951 (when adverse financial circumstances ended its publication). He then started the publication of entomological monographs in the series "Studia Entomologica," which with the support of the Conselho Nacional de Pesquisas became a journal in 1958 and is now (1976) in its 19th volume. In 1940 the Franciscans elected Father Thomas to the provincial government as one of the four counsellors, and at the same time he was made director of their publishing house "Vozes." His administrative duties as head of this large publishing company took much time and his taxonomic studies suffered until he retired from "Vozes" and moved to Jacarepagua in 1952 at the age of 60 years.

Living practically in seclusion, with only nominal duties as chaplain for the Catholic institution for blind women in Jacarepagua that he had founded in 1947, Father Borgmeier devoted the ensuing 20 years of his life to full-time systematic entomology. He closed his work on the army ants in 1955 with the publication of his monograph of the Ecitonini of the Neotropical Region (Studia Ent. 1:1–717) and turned his ant collection over to W. W. Kempf. He then plunged into a comprehensive taxonomic study of phorid flies, resulting in revisions of the Neotropical species (1958–1969, about 800 pp.), North American species (1963–1965, 575 pp.), Indo-Australian species (1966–1967, about 400 pp.), and a catalog of the Phoridae of the world (1968, 367 pp.). During his lifetime, Father Thomas published 243 papers in entomology and related subjects, totaling over 5,000 pages, and described more than 1,000 new species of phorid flies, about 100 species of ants, and a number of myrmecophilous beetles. His fine private collections of phorids and mrymecophilous beetles are now in the Museum of Zoology, Universidade de São Paulo, and his collection of Neotropical Formicidae is now in the hands of W. W. Kempf.

From 1959–1965, Father Borgmeier studied nearly 10,000 specimens of Phoridae from the United States National Museum of Natural History in Washington from which he determined about 500 species in 40 genera. Holotypes of 125 new species were deposited in the USNM collections. In 1965 the Smithsonian was able to purchase for a nominal sum from Father Borgmeier several hundred additional Neotropical phorids, mostly paratypes including more than 200 species not previously represented in the museum. During two extensive visits to Washington in 1961 and 1964 Father Thomas made many close personal friendships which included a number of members of the Entomological Society of Washington.

Thomas Borgmeier received many honors during his lifetime, all of which he accepted modestly and thankfully, as was his nature. He was the Brazilian delegate to the 5th International Congress of Entomology in Paris in 1932. He was awarded an honorary degree of Doctor of Science from St. Bonaventure University in New York in 1945. In 1955 he was elected as titular member of the Brazilian Academy of Science, and in 1962 he was the first recipient of the Costa Lima prize, instituted by the Seabra family and administered by the Academy. He was elected as a fellow of the Brazilian National Research Council in 1958 with the office of Pesquisador-Chefe. The Franciscan Order in 1965 conferred on him the honorary degree of Lector Generalis Jubilatus of the Order.

Thomas Borgmeier was a great man in the true sense of the word. We have listed here some of his innumerable tangible accomplishments. But his greatness probably lies even more in his intangible influence on his colleagues, friends, and students in the fields of entomology, education, religion, and publications, in each of which he was a recognized leader. Through personal dedication and with great sacrifice of time, effort, and money he almost singlehandedly kept two important entomological journals going for more than 40 years. Numerous distinguished Brazilian entomologists began as his students. Those of us who had the privilege of his guidance and his friendship join in tribute *in memoriam.*

W. W. Wirth, *Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560,* W. H. Robinson, *Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061 and* W. W. Kempf *(now deceased).*

SOCIETY MEETINGS

840th Regular Meeting—3 March 1977

The 840th Regular Meeting of the Entomological Society of Washington was called to order by President Ramsay at 8:00 p.m. on 3 March 1977, in the Ecology Theater of the National Museum of Natural History. Thirty-one members and nine guests were present. The minutes of the previous meeting were read and approved.

Membership Committee Chairman Utmar reported that 50 members were admitted to the Society in 1976. Three life members were announced:

Hans Ulrich of Bonn, Germany, the Society's first foreign Life Member, Lloyd Knutson, and Joyce Utmar.

The following new applicants for membership were read for the first time by Membership Chairman Utmar:

Albert E. Cole, Director, W. Va. Dept. of Agri., Plant-Pest Control Div., Charleston, W. Va. 25305.
Eric M. Risher, 902 Temple Av., Long Beach, California 90804.
Werner L. Jakob, CDC, P.O. Box 2087, Ft. Collins, Colo. 80522.
Tim L. McCabe, New York State Museum & Science Service, Albany, N.Y. 12224.
Henry E. Sprance, Dept. of Ent., Univ. of Maryland, College Park, Md. 20742.
William Wills, Pa. Dept. of Environ. Res., Med. Ent. Lab. 1, P.O. Box 1467, Harrisburg, Pa. 17120.

President-Elect Sutherland reported that the Society's annual banquet will be tentatively held in June at the Chief Petty Officers' Club, Washington Navy Yard. Those attending will be guests of Victor Adler. There was no discussion or disagreement with these arrangements.

President Ramsay announced that the Washington Academy of Science will meet on April 21st. The subject of the program is "Signalling by Fireflies."

President Ramsay requested volunteers to serve as judges for the Fairfax Co. Regional Science and Engineering Fair.

The program for the evening, presented by Dr. John M. Kingsolver, Systematic Entomology Lab., was entitled "Bruchidae: Specialists in Seeds." Dr. Kingsolver reviewed the distribution and life history of Bruchidae, or seed weevils. All bruchids spend larval stages in or on seeds. Most of the economically important species attack commercial legumes. They vary in host specificity; some attack one species or genus of plant; others have members of 15 families as hosts. Morphology of adults and affinities to Chrysomelidae were noted. Finally, Dr. Kingsolver showed slides illustrating plant associations, mostly from Costa Rica. Examples of toxic plant hosts and secondary invasion of seeds by other bruchid species were shown.

Several guests were introduced.

Notes and Exhibitions

Robert Nelson said that he received a letter from Lou Davis, now living in California. Lou recently called Mr. & Mrs. Mort Armitage.

Curtis Sabrosky reported that the Proceedings of the XVth International Congress of Entomology will be printed and bound this month and should be in the mail by the end of March. One copy will be mailed free to the registrants of the Congress. Additional copies may cost more than the original estimate of $9.00.

An exhibit of insect artifacts—insect motifs in man-made objects—was arrayed on three tables. Over 13 exhibitors showed insects on fabric, shirts, neckties, needlework, plates, glasses, toys, pillboxes, small sculptures, pictures and plaques, jewelry, and other ornaments. Eleven orders of insects were represented.

The meeting was adjourned, after which cookies and punch were served.

Joyce Utmar, Recording Secretary, *pro tem*

841st Regular Meeting—7 April 1977

The 841st Regular Meeting of the Entomological Society of Washington was called to order by President-Elect Sutherland at 8:00 PM on 7 April 1977, in the Ecology Theater of the National Museum of Natural History. Twenty-one members and 10 guests were present. The minutes of the previous meeting were read and approved.

President Ramsay was excused due to illness.

No new applications for membership were received during the past month but 2 new life members were announced:

Robert W. Carlson, Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C.

Paul J. Spangler, Department of Entomology, Smithsonian Institution, Washington, D.C.

Treasurer Thompson announced that the Society has a new contract with the printer, Allen Press, which should allow publication of more pages at the same cost. President-Elect Sutherland reported that the annual banquet of the combined memberships of our Society and the Washington Insecticide Society will be held on Thursday, June 2nd at the Chief Petty Officers' Club, Washington Navy Yard. Tickets for the banquet will be available soon. President-Elect Sutherland also reported that the final plans were being made for the picnic-collecting outing to be held on the weekend of May 14th. A map to the area will be provided at the next meeting.

The main speaker for the evening was Dr. William E. Bickley, Agricultural Experiment Station, University of Maryland. Dr. Bickley spoke on transmission of dog heartworm by mosquitoes in Maryland. After presenting an overview of the life cycle, Dr. Bickley discussed his research and that of his students on evaluating the vector potential of three species of mosquitoes. He reported that *Culex salinarius* Coquillett is only marginally successful as a vector but that *Aedes canadensis* (Theobald) and *Aedes vexans* (Meigen) are likely candidates to act as vectors of the microfilariae. Dr. Bickley's talk was illustrated with many Kodachrome slides and following the presentation, several questions were asked concerning the disease.

Notes and Exhibitions: Ashley B. Gurney showed 25 slides of insects he has encountered on trips to South America and from around his home. Curtis Sabrosky announced that recent earthquakes in Romania had caused considerable damage to the museum in Bucharest as reported by Dr. Weinberg, an asilid expert at the museum.

Several guests were introduced including Dr. Roger W. Crosskey and Mr. Brian R. Pitkin from the British Museum (Natural History). Dr. Crosskey spoke briefly on the progress of the Afro-tropical catalogue of Diptera, which the dipterists at the British Museum are preparing.

The meeting was adjourned at 9:34 PM, after which punch and cookies were served.

Wayne N. Mathis, *Recording Secretary*

842nd Regular Meeting—5 May 1977

The 842nd Regular Meeting of the Entomological Society of Washington was called to order by President Ramsay at 8:05 PM, on 5 May 1977, in the Ecology Theater of the National Museum of Natural History. Twenty-two members and seven guests were present. The minutes of the previous meeting were read and approved.

Membership Chairman Utmar read for the first time the names of the following new applicants for membership:

Zehra Imran Ali, c/o K. M. Hussain, 4 Captain Drive, Watergate Apt. 311. Emeryville, California.
Ron Cave, 801 Jamaica Way, Bakersfield, California.
William P. Foerster, 1911 W. St. John's Ave., Austin, Texas.
Pierre Paul Harper, Department des Sciences Biologiques, Universite de Montreal, Quebec.
William P. Magdych, Department of Zoology, University of Oklahoma, Norman, Oklahoma.
Arnold Mallis, 3406 Chiswick Court, Apt. 2C, Silver Spring, Maryland.
Harry Myers, Box 1034, Wiley Hall, West Lafayette, Indiana.
Sandra S. Vincent, 12 C Plateau Place, Greenbelt, Maryland.

President Ramsay announced that Rosella Warner-Spilman has been granted emeritus status by the unanimous vote of the Executive Committee.

Program Chairman Hellman reviewed plans for the upcoming collecting/picnic outing being sponsored by the Society. The outing will be held during the weekend of May 13th and 14th at Merrit 4-H camp in Charles County, Maryland. There will be a pot-luck dinner Friday evening and 6 or 7 cabins will be available for sleeping. Activities other than collecting will be canoeing, fishing, and fun. Maps were available.

President-Elect Sutherland noted that the annual banquet is scheduled for June 2nd and that the guest speaker will be Dr. Dale F. Bray, University of Delaware. He encouraged the membership to purchase tickets early and noted that there will be a cash bar.

Editor Stoetzel reported that there will be a new format for the *Proceedings* which should allow publication of more pages for the same price. The format will have more print per page, larger type, and different paper. She asked for suggestions or comments from the membership concerning the format. Editor Stoetzel also announced that funds are available for another *Memoir* and that the Editorial Committee was soliciting manuscripts.

The main speaker for the evening was Dr. Jeffery P. LaFage form the National Pest Control Association. Dr. LaFage spoke on "Some New Ideas in Termite Ecology." Dr. LaFage described his research on two dry wood termites in Arizona and illustrated his talk with several excellent Kodachrome slides. An interesting discussion period followed the talk.

Notes and Exhibitions: Ted Bissel noted the existence of the Maryland Entomological Society, showed a recent publication of the society, and encouraged attendance at their monthly meetings at Catonville, Maryland.

Manya Stoetzel introduced John Beardsley from the University of Hawaii and also announced that the Burkses (Barney and Kellie) will be moving to Arizona.

The meeting was adjourned at 9:34 PM, after which punch and cookies were served.

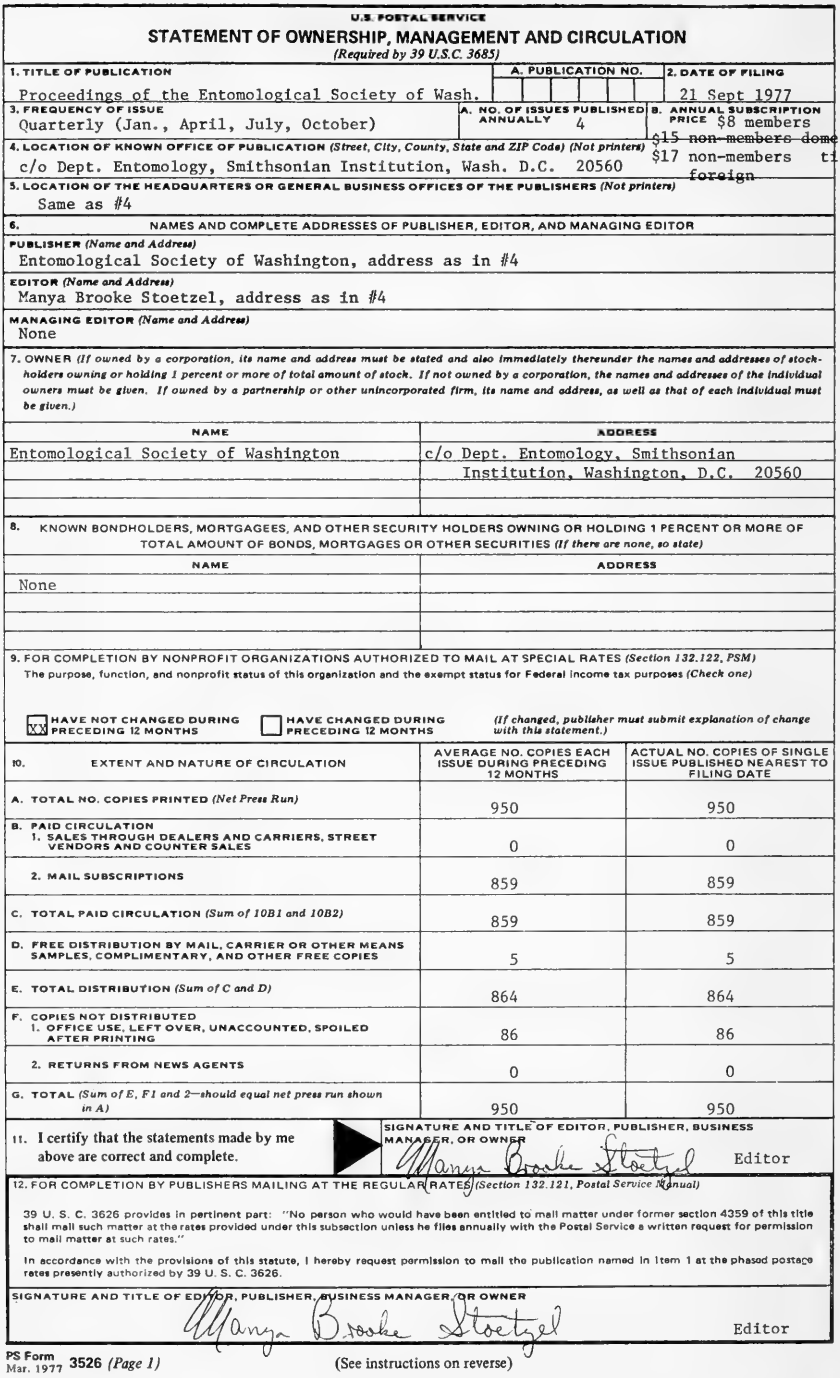
Wayne N. Mathis, *Recording Secretary*

843rd Regular Meeting—2 June 1977

The combined Annual Banquet of the Entomological Society of Washington and the Insecticide Society of Washington was held 2 June 1977, at the Chief Petty Officers' Club, Washington Navy Yard. The evening was presided over by Dr. Maynard Ramsay, President of the ESW, and Mr. John Kennedy, Chairman of ISW.

Mr. William Helms was Master of Ceremonies. Following the social hour and buffet dinner, 127 members and guests heard Dr. Dale F. Bray, University of Delaware, discuss "Lesser Known Biological and Cultural Pest Control Techniques." Mr. and Mrs. F. F. Smith provided custom designed floral arrangements. Dr. John Neal conducted drawings for floor prizes which were provided by members and industry.

D. W. S. Sutherland, *Recording Secretary, pro tem*



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SYNOPSIS OF THE NORTH AMERICAN PYRGOTIDAE (DIPTERA)

George C. Steyskal

Abstract.—A key to all species of Pyrgotidae known to occur north of Mexico is given. The new genus *Boreothrinax* (type of genus, *Oxycephala maculipennis* Macquart) is described and two new species, *Boreothrinax dichaetus* (Arizona and Mexico) and *B. shewelli* (British Columbia to Colorado) are referred to it.

The Pyrgotidae may sometimes cause a marked decrease in the number of soil grubs (larvae of scarabaeid beetles) by parasitizing the adults. The female flies have a remarkedly specialized ovipositor for inserting eggs into the abdomen of the beetles in flight. Because most species of their hosts fly at night, so do the pyrgotids.

Although about 330 species of Pyrgotidae are known from all major regions of the world, only eight species in five genera are known from America north of Mexico. References to previously described species, synonymy, etc., may be found in Steyskal, 1965.

Key to Genera and Species of North American Pyrgotidae

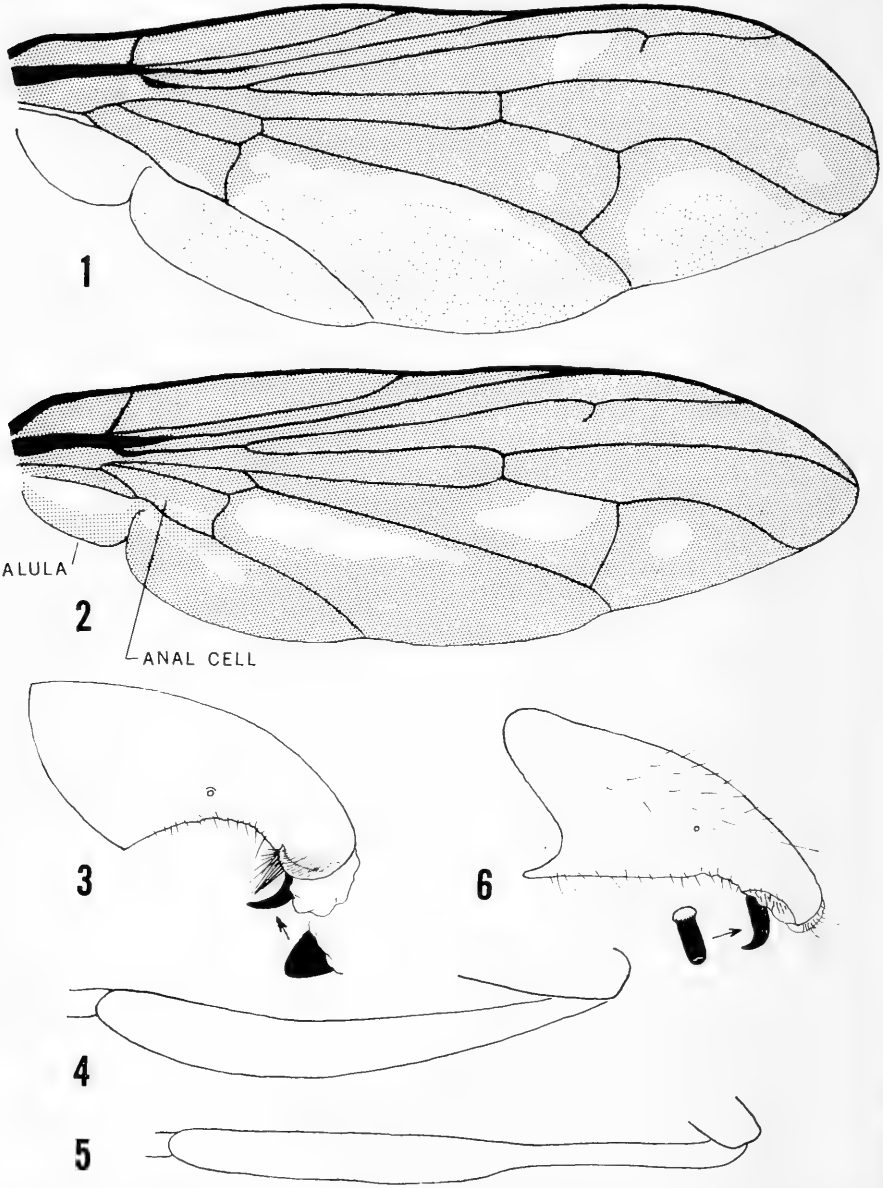
1(2). Posterior apical corner of anal cell 90°, vein closing cell straight; alula rudimentary; face with single cuplike depression, without median keel; body without strong bristles, even on scutellum (Minnesota to North Carolina and northeastward) *Pyrgotella chagnoni* (Johnson)

2(1). Posterior apical corner of anal cell much less than 90°; alula well developed or absent; face with or without median keel separating antennal grooves; body usually with strong bristles.

3(4). Face without median keel; alula lacking; vein closing anal cell straight, but forming acute anal with posterior side of anal cell; body without strong bristles (northward into Arizona) *Stenopyrgota mexicana* Malloch

4(3). Face with median keel separating antennal grooves; alula present (Figs. 1, 2); vein closing anal cell sinuate; body with strong bristles.

5(8). Wing (Figs. 1, 2) with large areas of plain color, not mottled; 2nd vein usually with stump vein extending backwards near tip; hindtibia tapering to base (Fig. 4); female with strong hook (often more or less withdrawn) below at tip of abdomen (Fig. 3) Genus *Pyrgota*



Figs. 1–6. Details of Pyrgotidae. 1. *Pyrgota undata*, wing; 2. *Pyrgota fenestrata*, wing; 3. *Pyrgota undata*, lateral view of female postabdomen; 4. *Pyrgota undata*, lateral outline of hindtibia; 5. *Boreothrinax shewelli*, lateral outline of hindtibia; 6. *Sphecomyiella valida*, lateral view of female postabdomen.

6(7). Wing (Fig. 1) with hyaline to pale-brown posterior areas open to margin of wing (Manitoba to Texas and eastward) *Pyrgota undata* Wiedemann

7(6). Wing (Fig. 2) with hyaline to whitish areas enclosed ("Carolina" to Florida) *Pyrgota fenestrata* (Macquart)

8(5). Wing with rather finely mottled pattern, without large areas of plain color; 2nd vein without stump vein; hindtibia various; female abdomen with or without apicoventral hook.

9(10). Hindtibia tapering to base (Fig. 4); ocellar and postocellar bristles usually well developed (ocelli absent); prosternum with lateral setae; female ovipositor sheath (Fig. 6) with strong hook at tip below, which may be more or less withdrawn (Minnesota to Texas and eastward) *Sphecomyiella valida* (Harris)

10(9). Hindtibia strongly constricted near basal ⅓ (Fig. 5); ocellar bristles usually lacking, postocellars lacking (ocelli absent); prosternum setose or bare; female ovipositor sheath (Figs. 9, 10, 12) without apicoventral hook *Boreothrinax*, new genus

11(12). Length of wing 9.3–12.0 mm; prosternum bare; female postabdomen as in Fig. 9; male postabdomen as in Fig. 8 (British Columbia to Colorado) *Boreothrinax shewelli*, new species

12(11). Length of wing less than 9 mm (south and east of Colorado).

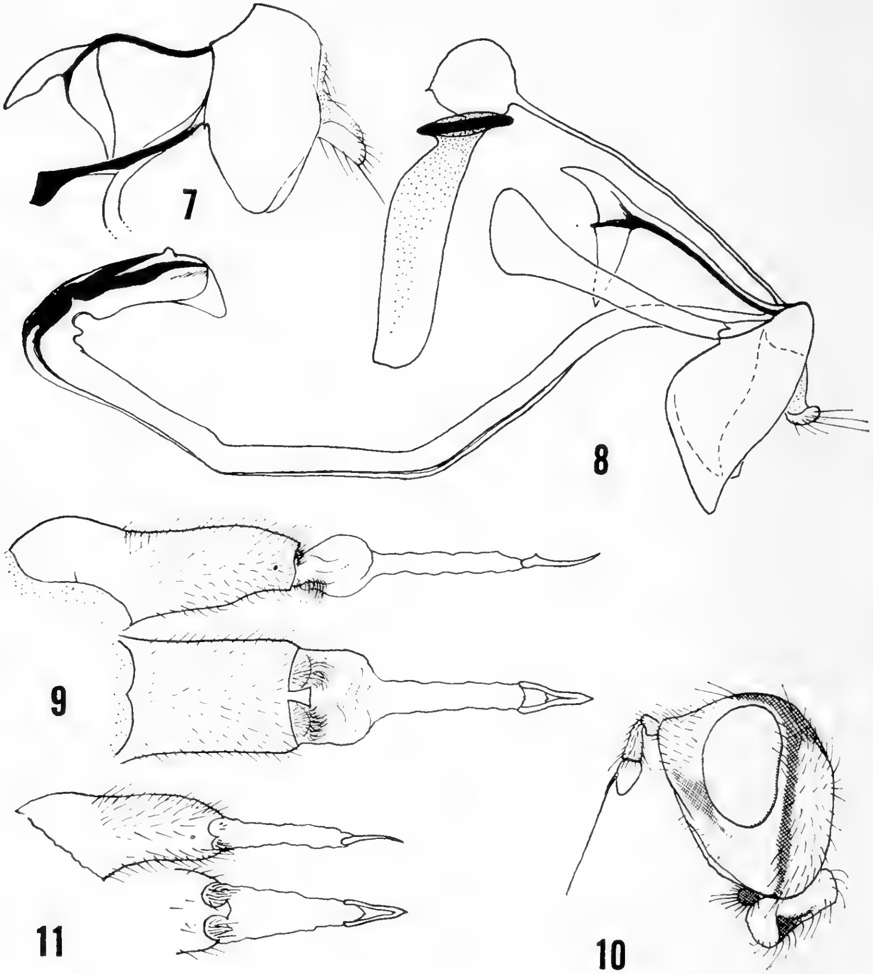
13(14). Length of wing 7.0–8.4 mm; prosternum bare; female postabdomen with spiracle close to tip, without apicolateral lappets (Fig. 11); male postabdomen as in Fig. 7 (Maryland, Iowa, Arizona, and southward) *Boreothrinax maculipennis* (Macquart)

14(13). Length of wing 5.7–7.7 mm; prosternum with fine lateral setae; female postabdomen with spiracle closer to midlength than to tip, with pair of circular apicolateral lappets (Fig. 12); male postabdomen as in Fig. 13 (Huachuca Mountains, Arizona and Mexico) *Boreothrinax dichaetus*, new species

Boreothrinax Steyskal, new genus

Type of genus, *Oxycephala maculipennis* Macquart.

The sinuate vein at tip of apical cell, well-developed alula and median facial keel, and irrorate wing pattern bring this member of the tribe Pyrgotini into comparison only with *Sphecomyiella* Hendel, from which it differs as in the above key. The only known species besides the type of the genus are the new species described below. The name is of masculine gender and similar to a few names derived from Greek *thrinax* by Enderlein.



Figs. 7–11. Details of *Boreothrinax* species. 7. *Boreothrinax maculipennis*, lateral view of male postabdomen, less aedeagus; 8. *Boreothrinax shewelli*, lateral view of male postabdomen; 9. *Boreothrinax shewelli*, lateral and ventral views of female postabdomen; 10. *Boreothrinax shewelli*, profile of head; 11. *Boreothrinax maculipennis*, lateral and ventral views of female postabdomen.

Boreothrinax dichaetus Steyskal, new species
Figs. 12, 13

Differing from *B. maculipennis* and *B. shewelli* as in the preceding key; general color somewhat darker than in either of these species, with apical ⅔ of 3rd antennal segment and most of femora blackish; size intermediate, with length of wing 5.7–7.7 mm. Prosternum with about 5 fine lateral setae.

Female postabdomen as in Fig. 12; ovipositor sheath longer and more slender than in other species, with pair of circular lappets at lateroventral apex, conspicuous pair of long ventral bristles, and spiracles little apicad of midlength of sheath.

Male postabdomen as in Fig. 13; epandrium in profile bluntly and obliquely truncate, roughly elliptical.

Types.—Holotype, allotype, and 1♂ and 3♀ paratypes, Huach. (= Huachuca) Mts., Ariz., Catal. No. 1311, Brooklyn Museum Coll. 1929 (No. 73650 in U.S. National Museum); paratypes; 2♀, Miller Canyon, Huachuca Mountains, Cochise County, Arizona, I.V. and 19.VII.1969, 5,000 ft (R. F. Sternitzky); 1♀, 5 mi W Durango, Durango, Mexico, 29.VI.1964, 6,500 ft (J. F. McAlpine); 1♀, 11 mi W Durango, Durango, Mexico, 15.VI.1964, 7,000 ft (J. F. McAlpine), all in Canadian National Collection, Ottawa.

The species-name, an adjective meaning "two bristle," is derived from Greek.

Boreothrinax maculipennis (Macquart, 1846), new combination
Figs. 7, 11

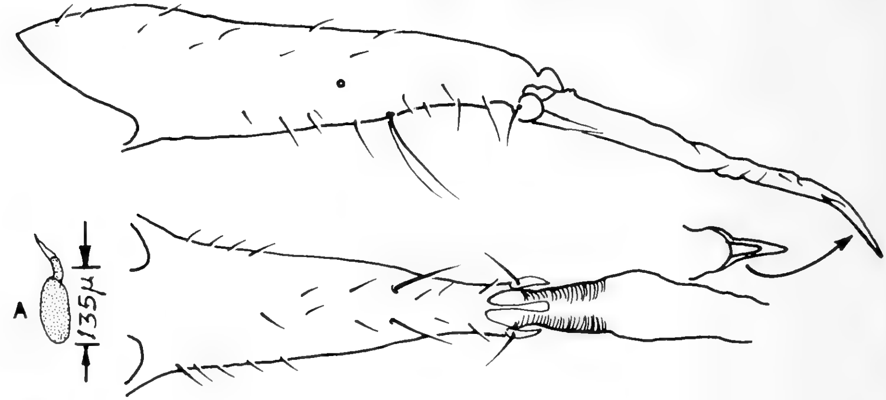
This species has been placed in *Sphecomyiella* in the North American Catalog (Steyskal, 1965), but the constricted hindtibia and the differences in the female postabdomen show that a new genus is required for it and the two new species here described. It is likely that other species will be found, especially south of the United States.

Boreothrinax shewelli Steyskal, new species
Figs. 5, 8–10

Very similar in coloration and external structure to *B. maculipennis*; paler than *B. dichaetus*, antenna and femora usually wholly tawny; larger (length of wing 9.3–12.0 mm) than *B. maculipennis* and *B. dichaetus*; and differing in postabdominal structure.

Head as in Fig. 10; prosternum bare; outline of hindtibia in lateral view as in Fig. 5; female postabdomen as in Fig. 9, base of ovipositubus much swollen and bearing 2 patches of dense, colorless hairs just apicad of black-setose patches at apex of ovipositor sheath; male postabdomen as in Fig. 8, epandrium acutely pointed and details of hypandrium, aedeagal apodeme, and cerci differing markedly from those of the other species.

Types.—Holotype and 1 paratype, ♂'s, Oliver, B.C., 13.V.1953 (D. F. Hardwick); allotype, Victoria, B.C., V.1916 (R. C. Treherne); ♂ paratype, Keremeos, B.C., 8.V.1923 (E. R. Buckell); ♀ paratype, Boulder, Colo., 18. VI.1961 (W. R. M. Mason); all in Canadian National Collection, Ottawa;



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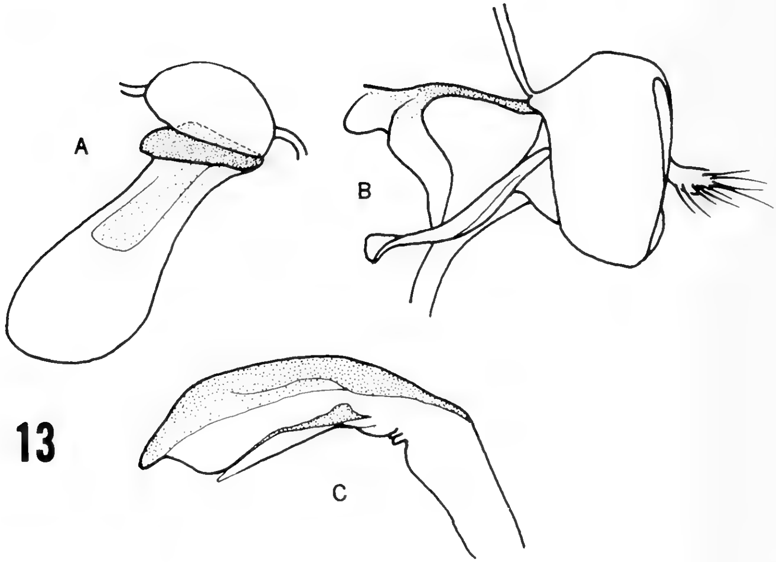

13

Figs. 12–13. *Boreothrinax dichaetus.* 12. Lateral and ventral views of female postabdomen, with (A) spermatheca; 13. Male postabdomen, with (A) sperm pump, (B) lateral view of postabdomen less sperm pump and apical part of aedeagus, and (C) tip of aedeagus.

paratypes in U.S. National Museum: 4♀, 1♂, Stratton Experimental Watershed, near Saratoga, Carbon County, Wyoming, 31.V–12.VI.1972 (J. M. Schmid), Hopkins No. 36775-J, at light; 1♀, Logan, Utah, 1.VI.1939 (G. F. Knowlton, G. S. Stains), Madras, Ore. (Ore. Dept. Agr.).

The species is dedicated to Guy E. Shewell, who first recognized the distinctness of the species, and in gratitude for many favors.

Stenopyrgota mexicana Malloch

1929 Ann. Mag. Nat. Hist. (10)3:259.

Malloch described this species from a female specimen (now in U.S. National Museum) taken at an elevation of 7,300 ft at Rio Piedras Verdes, Sierra Madre, Chihuahua, Mexico. I have examined that specimen and 1 each from Fortin de las Flores, Veracruz, Mexico (in Florida State Collection of Arthropods) and Nicaragua (U.S. National Museum). A female specimen taken 0.7 mi SW Turkey Creek, Chiricahua Mountains, Cochise County, Arizona, 13.VII.1966 (R. G. Beard), examined and returned to Southwestern Research Station of the American Museum of Natural History, is the first record of the species north of Mexico.

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Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. Educ. Admin., USDA c/o U.S. National Museum, Washington, D.C. 20560.

PROC. ENTOMOL. SOC. WASH.
80(2), 1978, pp. 156–163

THREE NEW NEOTROPICAL *RHIZOECUS* (HOMOPTERA: PSEUDOCOCCIDAE)

Edson J. Hambleton

Abstract.—Three new species in the genus *Rhizoecus* Künckel d'Herculais, *R. divaricatus* from Nicaragua, *R. olmuensis* from Chile and *R. variabilis* from Colombia, are described and illustrated. *Rhizoecus divaricatus* is a pest of coffee and is the first known species of the genus from Nicaragua.

Among several collections of mealybugs received for identification are three undescribed species of *Rhizoecus* from Central and South America. With the addition of *R. divaricatus* from Nicaragua, a total of 14 species of *Rhizoecus* are known to occur in the American tropics on the roots of coffee. Three other species of closely related genera of the tribe Rhizoecini also occur on coffee. The new species, *R. olmuensis* and *R. variabilis*, are from Chile and Colombia respectively. *Rhizoecus variabilis* was found on *Agave* sp., but the host of *R. olmuensis* is unknown.

The genus *Rhizoecus*, with the three species described as new, contains 60 species for the Western Hemisphere. My key to the species (1976) is revised to accommodate the new species as follows:

4(3). "Antennae 6-segmented ... *sonomae* McKenzie"
– Antennae 5-segmented ... A
A(4). With 1 circulus; sensory setae not clavate; tubular ducts present ... *californicus* Ferris
– With 2 circuli; sensory setae clavate; tubular ducts absent ... *divaricatus*, new species

and

37(36). Anal lobes sclerotized; anal ring 45–60 μ wide; rostrum 51–57 μ long ... 38
– Anal lobes unsclerotized; anal ring 68–78 μ wide; rostrum 65–95 μ long ... B
38(37). "Anal ring about 60 μ wide, its setae about 87 μ long, outer part with 25–30 large, angular, irregularly quadrate, mostly isolated cells; orifice of circulus narrow, less than ½ its basal width ... *floridanus* Hambleton"
– "Anal ring about 45 μ wide, its setae about 55 μ long, outer part with 19–20 small, elongate, oval cells almost touching end to end; orifice of circulus wide, more than ½ its basal width ... *tropicalis* Hambleton"
B(37). Tubular ducts absent; with 250 tritubular cerores ... *olmuensis*, new species
– Tubular ducts present; with 45–145 tritubular cerores ... 39

39(B). Tubular ducts varying in size, complex in design; with 130–145 tritubular cerores; apical segment of antennae less than 2× as long as wide; sensory seta on segment V short, stout *relativus* Hambleton

– Tubular ducts about same size, of simple design; with 45–50 tritubular cerores; apical segment of antennae 2× as long as wide; sensory seta on segment V narrow, elongate *ovatus* Hambleton

and

41(40). "Digitules at least ½ as long as claws, hind claw about 40 μ long; rostrum about 80 μ long and 78 μ wide; with 35–40 tritubular cerores; lobe setae about same size as ring setae *maritimus* (Cockerell)"

– Digitules less than ½ as long as claws, hind claw 24–26 μ long; rostrum 69–73 μ long; lobe setae shorter and more slender than ring setae C

C(41). Anal ring 80 μ in diameter; 46–48 cells of outer part without spicules; cephalic plate absent; circulus dome shaped, 36 μ wide at base *variabilis*, new species

– Anal ring 57 μ in diameter, 24–30 cells of outer part with spicules; cephalic plate present; circulus conical, about 19 μ wide at base *arabicus* Hambleton

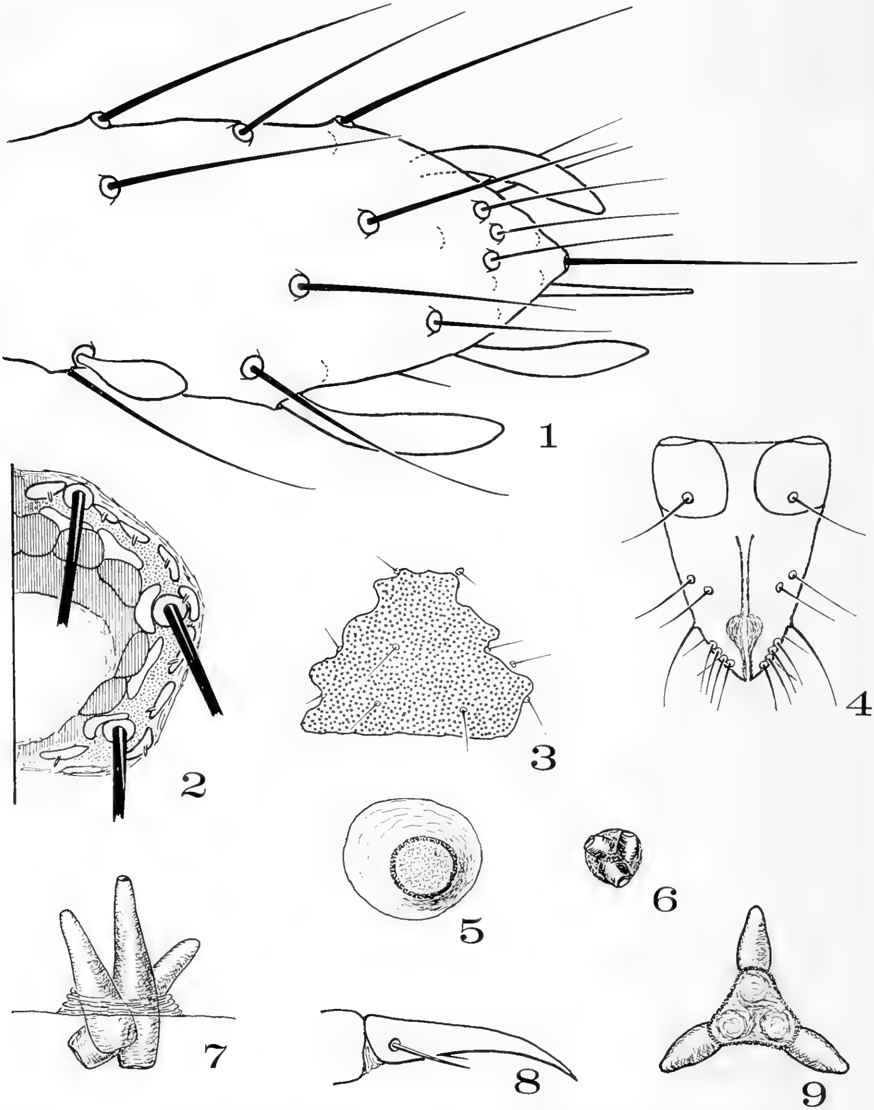
Rhizoecus divaricatus Hambleton, new species

Figs. 1–9

Adult female.—Oval elongate, stout, broadest across abdomen. Length, 1.63–2.16 mm; width, 0.95–1.11 mm. Antennae 5-segmented, rather stout, average length of segments in microns: I, 35; II, 23; III, 30; IV, 19; V, 75; apical segment 2× as long as wide, with 4 stout, clavate sensory setae that taper distally, and 1 spinelike sensory seta near apex. Interantennal space about length of segment I. Eyes absent. Rostrum of medium size, averaging 67 μ long, 53 μ wide; rostral loop reaching 2nd coxae. Cephalic plate irregularly triangulate, 8–10 small body setae on or near its periphery, length 53 μ, width, 63 μ. Dorsal ostioles strongly sclerotized, with body setae and pores bordering ostiole rims.

Legs moderately short, stout, average length of segments of hind pair in microns: Trochanter, 46; femur, 94; tibia, 88; tarsus, 72; claw, 27; digitules short, setose, not reaching to ½ length of elongate, narrow claws.

Two conical circuli, 16 μ wide at base, 1 each on abdominal segments III and IV. Anal lobes each with strongly sclerotized protruding area, longer than width of anal ring, and 12–14 subequal elongate setae, longest 80–83 μ long. Anal ring of medium size, about 46 μ wide, its setae stouter than longest anal-lobe seta, about 60 μ long; outer portion of anal ring



Figs. 1–9. *Rhizoecus divaricatus*, female. 1. Terminal segment of antenna; 2. Anal ring, right half; 3. Cephalic plate; 4. Rostrum; 5. Circulus; 6. Tritubular ceroris, small, dorsal; 7. Tritubular ceroris, large, lateral; 8. Hindclaw; 9. Tritubular ceroris, large, ventral.

with 18 small, oval, elongate cells, each with elongate spicule; inner portion of ring with 8–12 larger, more elongate cells, some serpentine shaped, adjacent to 8–10 large, darkened, globular cells. Tritubular cerores of 2 types, 14 large ones with stout, tapering, divaricating ducts ranging between 15–24 μ long, occurring dorsally on or near body margins and along middorsal line, 8 ventrally and submarginally slightly smaller; the remaining 16–21 cerores about ½ size of larger type with short, stout ducts, 8–9 μ long, occurring ventrally across abdominal segments V–IX, occasionally 1 on IV. Multilocular disk pores occurring ventrally, 21–49 scattered on abdominal segments VIII–IX, 5–8 along posterior border of VII, 1–6 on VI. Tubular ducts absent. Trilocular pores fairly evenly distributed but sparse in some areas. Body setae sparse, mostly short, inconspicuous, larger setae about 60 μ long.

Holotype female.—Nicaragua: Granada, 5-I-1975, José Gonzales, on roots of *Coffea arabica*; paratypes, 5 mounted on 2 slides, taken with holotype. All in USNM.

This interesting mealybug keys to *R. californicus* Ferris but differs by possessing only 38–45 cerores of 2 types, by having 2 circuli, by its stout, clavate sensory setae, and by the absence of tubular ducts. *Rhizoecus divaricatus* most closely resembles *R. vitis* Borchenius from the Crimea. It differs primarily by having 2 instead of 3 circuli, a large triangulate cephalic plate, and no tubular ducts. *Rhizoecus divaricatus* is the first recorded species of the genus from Nicaragua.

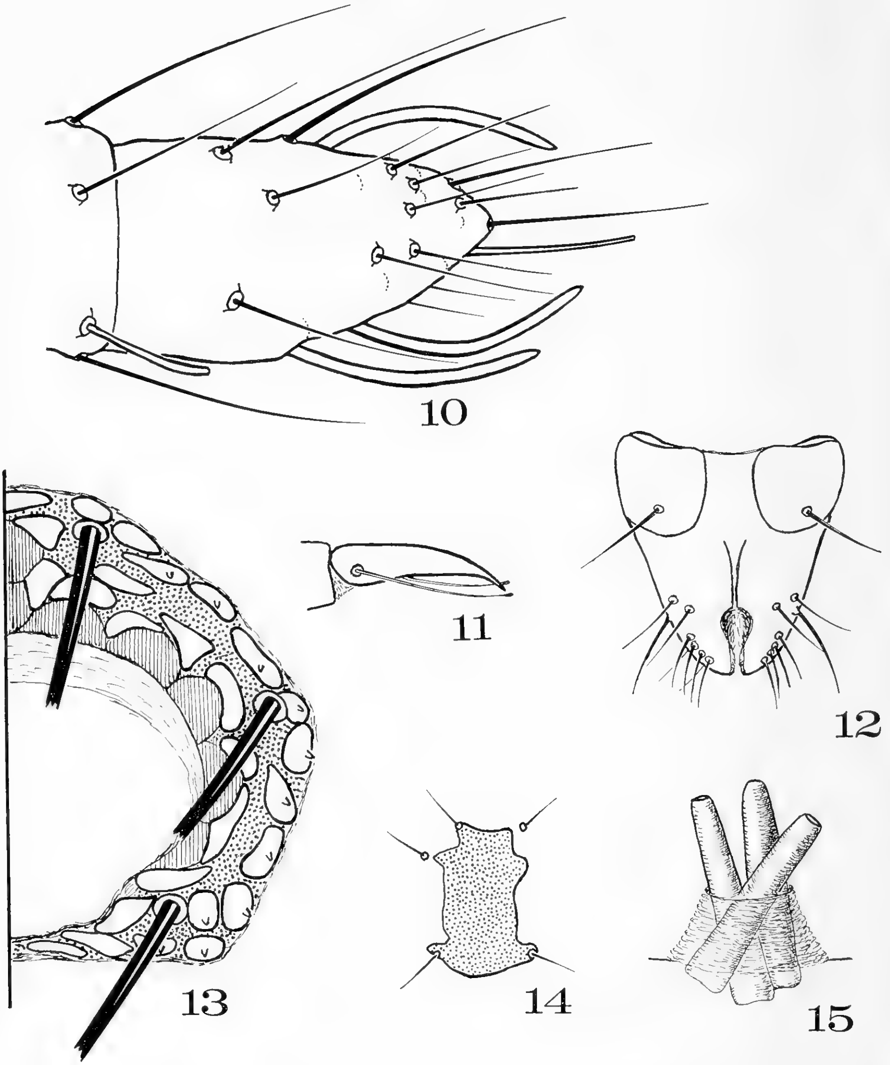
Rhizoecus olmuensis Hambleton, new species

Figs. 10–15

Adult female.—Undistended body elongate. Length, 0.94 mm; width, 0.37 mm. Antennae 6-segmented, of medium size, length of segments in microns: I, 28; II, 22; III, 28; IV, 20; V, 19; VI, 43; apical segment less than 2× as long as wide, with 3 narrow, elongate falcate sensory setae and 1 slender, spinelike sensory seta; segment V with 1 shorter, elongate sensory seta. Interantennal space equal to length of segment I. Eyes absent. Rostrum 65 μ long, 57 μ wide; rostral loop reaching beyond 2nd coxae. Cephalic plate 38 μ long, 30 μ wide, irregularly quadrate, with 4–5 body setae on its periphery. Dorsal ostioles conspicuous, sclerotized, pores and setae not crowded near ostiole rims.

Legs of medium size, length of segments of hind pair in microns: Trochanter, 40; femur, 83; tibia, 73; tarsus, 51; claw, 20; digitules slender, dilated apically, extending to or slightly beyond apex of stout, acute, curved claws.

One conical circulus, about 10 μ in diameter as base. Anal lobes undeveloped, unsclerotized, each with 3 elongate setae, longest about 57 μ



Figs. 10–15. *Rhizoecus olmuensis*, female. 10. Terminal segments of antenna; 11. Hind claw; 12. Rostrum; 13. Anal ring, right half; 14. Cephalic plate; 15. Tritubular ceroris, lateral.

and several body setae. Anal ring prominent, 74 μ wide, its setae stouter and longer than anal-lobe setae, 77–82 μ long; outer portion of anal ring with about 28 irregularly oval or triangulate cells, most with short, blunt spicules; inner portion of ring with 18–20 elongate curved to triangulate cells adjacent to area of darkened, globular cells. Tritubular cerores of medium size, 4.5–5.0 μ wide, their ducts about 7 μ long, about 250 well distributed over derm, occurring with setae and pores, forming bands around segments, leaving clear areas intersegmentally. Multilocular disk pores and tubular ducts absent. Trilocular pores fairly abundant, more numerous dorsally. Body setae variable in size and length, longest about 40 μ long, uniformly distributed.

Holotype female.—Chile: El Granizo, Olmue, Valparizo Prov., 5-IV-1961, L. Campos. Host unknown. In University of California at Davis.

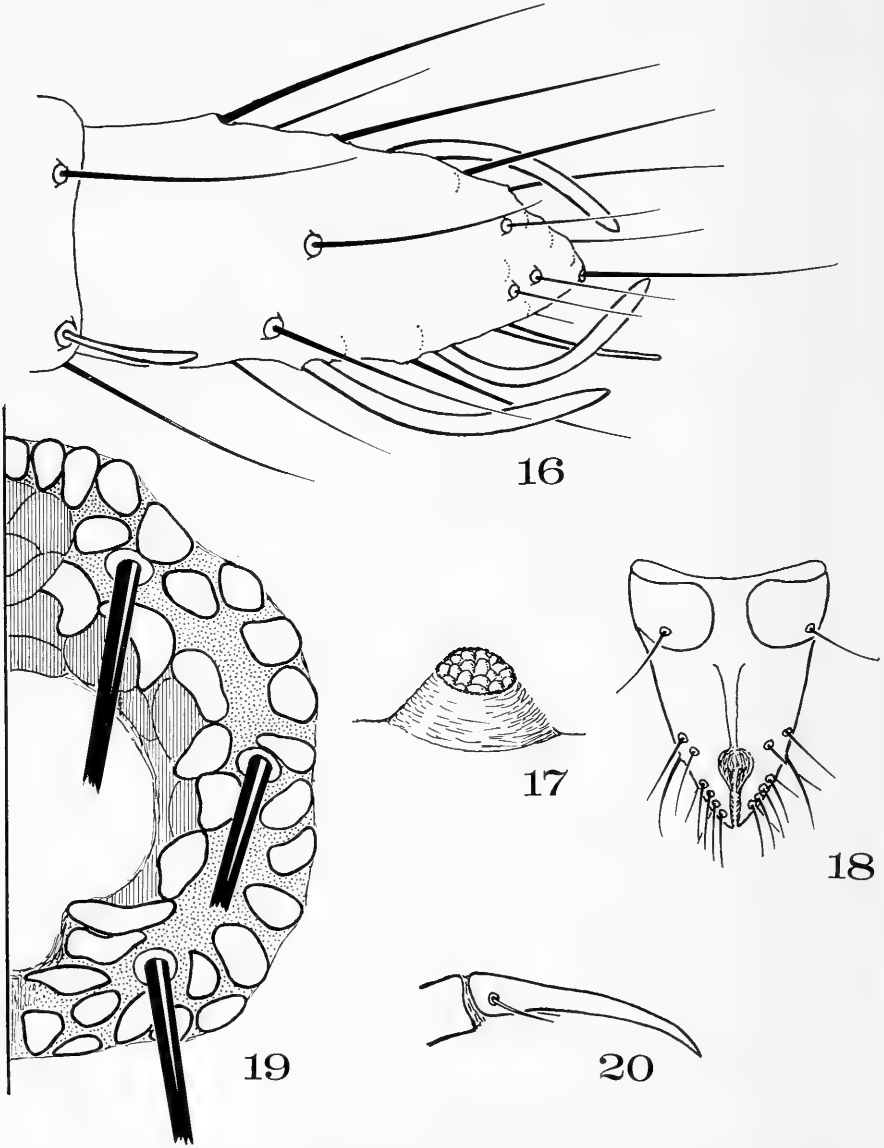
The description of *R. olmuensis* is based on a mature undistended female, consequently the body measurements given are tentative. In the revised key this species places close to *R. relativus* Hambleton. The absence of tubular ducts and greater number of cerores in *olmuensis* readily separate the two species. In general appearance *olmuensis* resembles *R. advenoides* Takagi and Kawai from Japan but differs in the absence of eyes, multilocular disk pores and tubular ducts.

Rhizoecus variabilis Hambleton, new species
Figs. 16–20

Adult female.—Oval elongate. Length, 1.75–2.19 mm; width, 0.85–1.20 mm. Antennae 6-segmented, elongate, average length of segments in microns: I, 34; II, 25; III, 49; IV, 20; V, 20; VI, 59; apical segment 2× as long as wide, with 3 elongate, medium-sized falcate sensory setae and 1 shorter, strongly tapered sensory seta; segment V with 1 smaller, weakly lanceolate sensory seta. Interantennal space equal to combined length of segments IV–VI. Eyes small, hemispherical. Rostrum averaging 73 μ long, 57 μ wide; rostral loop extending beyond halfway to 2nd coxae. Cephalic plate apparently absent. Dorsal ostioles inconspicuous, weakly sclerotized, bordered by few setae and pores.

Legs moderately stout, elongate, average length of segments of hind pair in microns: Trochanter, 51; femur, 143; tibia, 110; tarsus, 67; claw, 26; digitules short, setose, variable in length, sometimes about as long as slender claws.

One domed-shaped, faveolate circulus, 36 μ wide at base, 15 μ across orifice. Anal lobes undeveloped, each lobe area with 1 elongate seta, about 88 μ long and 2 shorter setae. Anal ring large, well defined, 80 μ in diameter, ring setae averaging 91 μ long, longer and stouter than lobe setae; outer portion of anal ring with 46–48 oval, subtriangulate cells unevenly arranged; cells of inner portion of ring 24–26 in number, larger, more irregular, some elongate, bordered by a darkened, semicircular, cellular area. Tritubular cerores small, with finely tapered ducts, 55–65 present, widely distributed, more common dorsally. Multilocular disk pores absent. Tubular



Figs. 16–20. *Rhizoecus variabilis,* female. 16. Terminal segments of antenna; 17. Circulus; 18. Rostrum; 19. Anal ring, right half; 20. Hind claw.

ducts short, stout, their diameter less than that of trilocular pore, sparsely distributed over derm dorsally and ventrally. Trilocular pores numerous, fairly evenly distributed. Body setae mostly short, rather inconspicuous, variable in length, longest about 36 μ long.

Holotype female.—Colombia: Garagoa, 1-V-1973, F. Mosquera, on *Agave* sp., on slide with 2 paratypes, specimen in middle is holotype; paratypes, 6 taken with holotype. In USNM.

Rhizoecus variabilis keys to *R. arabicus* Hambleton, also from Colombia. However, *variabilis* is a larger species and is readily separated from *arabicus* by the size of its anal ring, whose cellular structure is without spicules, by the dome-shaped faveolate circulus, by the narrow claws, and by the absence of a cephalic plate.

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Cooperating Scientist, Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. Educ. Admin., USDA (mail address: 5140 Worthington Drive, Washington, D.C. 20016).

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80(2), 1978, pp. 164–170

AGGREGATIONS OF MALE SCREWWORM FLIES, *COCHLIOMYIA HOMINIVORAX* (COQUEREL) IN SOUTH TEXAS (DIPTERA: CALLIPHORIDAE)

E. S. Krafsur

Abstract.—Noted, for the first time, is the occurrence of aggregations of males of the screwworm fly, *Cochliomyia hominivorax* (Coquerel). The continuous presence of males in each of two sites in south Texas was independent of the presence of cattle or of female screwworm flies. Males captured in autumn 1975 proved to be wild; those captured in spring 1976 were released, sterile insects. The behavior of males, wild or sterile, included vigorous conspecific and interspecific interactions. There was evidence of territoriality and competition for favored perching sites. The observations are consistent with an hypothesis that the male screwworm aggregations were mating assemblies similar to those known among other cyclorrhaphan Diptera. The significance of male aggregation to sterile fly liberations is discussed.

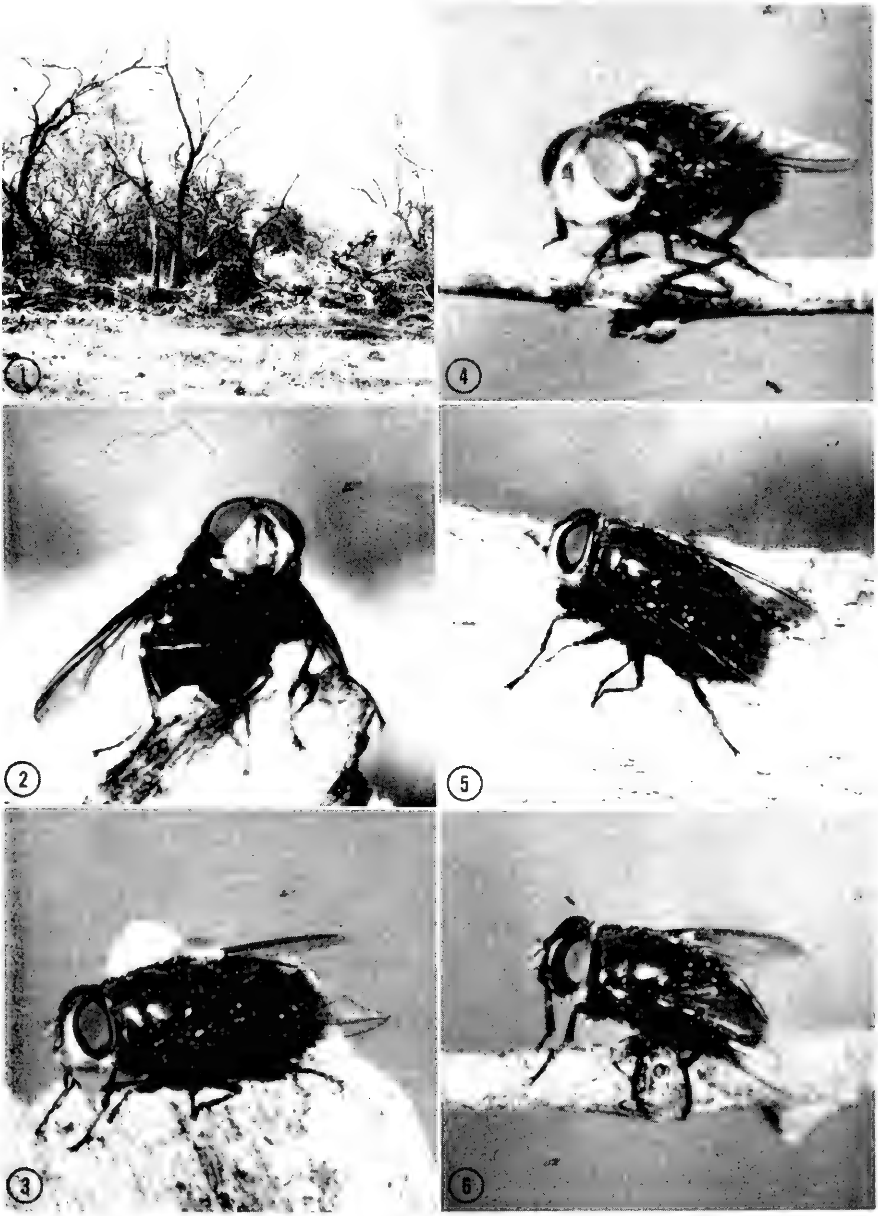
Sterile fly release strategy, as currently practiced in the USDA, Southwestern Screwworm Eradication Program, is predicated upon three factors. One is that sterile *Cochliomyia hominivorax* (Coquerel) must be applied to areas where breeding *may* be occurring because the probabilities of detecting cases of myiasis, particularly when prevalence is low, are rather poor. Another factor upon which sterile fly dispersions is based is that of scale: Vast areas are at risk to primary screwworm and while it is possible to learn where breeding occurs, it is much more difficult to know where it is not. Thus great effort must be put to distributing sterile flies in areas that indeed have no screwworms at all. For these reasons, program aircraft are scheduled to "grid" evenly the region at risk. Generally, an area is treated to sterile flies packaged in units of 1,800–2,200 (½ males) and distributed in lanes set 5 or 10 miles (8–16 km) apart,[1] "doses" of sterile flies varying with their availability and with case incidence reports submitted by ranchers, state, and federal personnel. The third consideration underlying sterile fly release strategy is the implicit assumption[2] that mating takes place after random dispersion of virgin flies from their pupation sites, a behavioral trait assumed to have evolved in order to prevent brother-sister matings and consequent inbreeding. This supposition justifies the practice of distributing sterile flies in parallel lanes and requires of males that they seek out mates up to several miles from the point of their release. That they have the ability and necessary behavioral traits necessary to accomplish this was never demonstrated. It is therefore of very practical importance that we learn the sequence of events leading to mating; failing this, that at least the operational premise of dispersion prior to mating is tested against such evidence as exists or can reasonably be inferred from data on related calyptrate fly species.

Observations

Two male screwworm aggregation sites, about 40 miles apart, were found in the thorny brush of northern Hidalgo County in south Texas. Male aggregation and mating behavior in screwworms has been heretofore unrecorded. The sites, wooded with *Acacia* spp. and mesquite (*Prosopis* spp.) up to about 7 m in height, were discovered in October 1975, and one of them (Fig. 1) was visited repeatedly until July 1976. Ladders were used when needed to gain access to perching sites. Where it proved impossible to get within a few feet of a specimen, identification was made through the use of a telescopic lens. Numerous color photographs were obtained. Discrimination of *Cochliomyia hominivorax* from *C. macellaria* (Fabricus) was easily accomplished visually. Captured material was used to confirm the identifications and some 16 crosses were made to laboratory-reared female *C. hominivorax* under controlled conditions (see below). *Cochliomyia macellaria* was commonly observed in the study locations, but males of this species were never observed to demonstrate the behavior characteristic of *C. hominivorax* to be described, nor to occupy similar resting and perching sites.

Numbers of male *C. hominivorax* actually observed (simultaneously) varied from two to many on any one day, but their speed and frequency of flight were such that they proved impossible to census accurately. Even when three observers were present, simultaneous sighting of more than eight flies was difficult. More males than actually enumerated may well have been present. There was available no means which allowed us to make an unbiased estimate of male numbers, as the males moved rapidly through three dimensions and were not always easy to see. No screwworm males were observed in other locations similar to the identified aggregation sites nor were any found after repeated searching throughout the areas surrounding the two sites. Why these locations were preferred is unknown, as there seemed to be nothing particularly distinguished about them.

The aggregations of screwworm males were not dependent on the presence of livestock. When the present observations were begun, cattle were no longer to be found in site A, and only small, transient numbers of them were observed nearby in the year following. Site B was the home of a substantial herd of cattle, among whom were individuals infested with screwworms. Pens of wounded, sentinel sheep (Davis et al., 1968) were established in both aggregation sites. Gravid female *C. hominivorax* oviposit on the wounds and the resulting number of egg masses can be taken as an index of screwworm population density. No confusion exists between wild



Figs. 1–6. *Cochliomyia hominivorax*, November 1975. 1. Aggregation site A. Trees are mesquite, *Prosopis*; 2–6. Male screwworms photographed in life, all on mesquite branches and twigs. Note that the flies face the sun.

Table 1. Weekly screwworm egg masses, mean temperatures, and reported incidence of myiasis in Hidalgo County, Texas, 1975.

	Week beginning									
	10/22	10/29	11/5	11/12	11/19	11/26	12/3	12/10	Avg.	Variance
Egg Mass Nos.										
Site A	—	1	13	1	0	1	0	0	2.3	22.6
Site B	5	18	24	9	0	0	0	0	7.0	87.7
Incidence[a]	23	33	22	23	4	9	11	7	16.5	102.9
Avg. temps °C	21.7	23.5	23.3	18.3	13.4	15.4	17.3	18.9	—	—

[a] Based on samples of larvae voluntarily submitted by ranchers to the Southwestern Screwworm Eradication Program, APHIS, USDA.

and released, irradiated females because ovarian development does not occur in radiosterilized flies. Of 72 egg masses collected (Table 1), only four were sterile (6%), suggesting that sterile male releases of about 1,540 km^2/week were ineffective. The number of ovipositions were few in the first week of sampling, were greatest in the second or third weeks and declined precipitously thereafter. Screwworm incidence in Hidalgo County, as indicated by samples of larvae submitted to APHIS for identification, fell off less sharply than the local populations sampled in sites A and B. It is important to note that temperatures (Table 1) were adequate to allow ovarian development and do not explain the virtual cessation of oviposition. The egg-mass-sampling distributions were strongly clumped, as suggested by high variance to mean ratios. These are typical of screwworm populations in Texas and Mexico (Krafsur and Hightower, unpublished). The absence (in site A) or presence (in site B) of cattle seemed to have little influence on female screwworm populations.

Males continued to be seen until early December, well after the apparent dispersion of female screwworms. Three captured males were each caged with five virgin, laboratory-reared females. That the flies were wild was confirmed because only fertile egg masses were obtained. One of the males was caught in site B while feeding on a fresh cow dropping.

No evidence of screwworms was obtained after the advent of cold weather in December. Despite the continuous presence of wounded sheep in site A, no egg masses were found until 26 April, but male screwworms were observed from 5 March onwards. Some 13 were caught over a 3-month period, and their fertility was tested by crossing them to laboratory-reared stock. All proved to be sterile, released flies. Females caught probing in wounds of the sentinel sheep also proved to be released flies, their ovaries failing to show evidence of yolk deposition after being held four days at 29°C. No male screwworms were observed on the sentinels, nor in their pens. Both sexes of *C. macellaria*, however, were frequent on sheep wounds and droppings. Nectar feeding among spring populations of screwworm males was suggested by the observation of heavy pollen deposits on some perching specimens.

Clear behavioral patterns were noted, and these were common to autumn, spring, and summer screwworm populations, being observed whenever the sites were visited, from 1000–1830 h. Resting males most frequently chose as perching sites prominent, leafless branches 3–6 m above ground level and facing open, sunny spaces. Distal perches were favored, but when these were occupied, exposed interstitial positions were assumed. Some male screwworms perched in leaves of the evergreen shrub, granjeno (*Acanthoceltus* spp.). Perching could easily be induced by holding up a stick or one's hand near a flight station or in one of the open "arenas." The new station usually would be taken by a nearby male. Characteristic, aggressive poses were adopted by perching males, heads up and abdomens down (Figs. 2–6). *Cochliomyia macellaria* were never seen to adopt such attitudes. When temperatures were about 20°C or higher, perching males periodically took off on short elliptical or circular flights; they quickly returned to the same positions unless displaced by another male. Vigorous interactions among screwworm flies were evident. A male occupying one site would reconnoiter other sites, and if occupied, interception and apparent conflict invariably occurred with two males flying off together in a mass of legs and wings, only to return to their respective stations. A perching male typically flew after screwworms, other fly species and even butterflies when these came within about 3 m of its resting position. Small numbers of perching sarcophagid and muscid males were occasionally noted.

On cool days, <20°C, perching behavior was less frequently observed, and males could more easily be found resting closely appressed to the internodes of mesquite branches and twigs, usually exposed to the sun. This resting behavior supports the observations of Hightower (1963), who recorded nocturnal resting sites of marked, released screwworms. When windy conditions prevailed in addition, flies were found resting on mesquite twigs, within 1 m of the ground and *C. macellaria* were observed to behave similarly at such times.

Discussion

Observations made simultaneously on male and gravid female screwworm flies are consistent with an hypothesis that local aggregation of a cohort of females is transitory, while that of males is not. In other Diptera, males taken from a swarm or waiting station were demonstrated to return to their aggregation sites (Downes, 1969; Hunter and Webster, 1973). The sequence of events for most female screwworms seems to be, eclosion, mating at 2–3 days of age, oviposition at 5–6 days (Hightower et al., 1972) (should suitable hosts locally exist) and dispersion. This interpretation is supported by the clumped distribution of ovipositions observed in this and unpublished work conducted in Texas and Mexico. The sampling distribution of egg masses, typically aggregated spatially and temporally, probably arises from a similar distribution of larvae in their vertebrate hosts a generation earlier. Random dispersion before mating is the alternative. The hypothesis is unlikely. Recapture of sterile females is maximal on the third or fourth day after release, when the flies are 4–5 days old and already mated (Hightower, 1969). *Cochliomyia hominivorax* exist in characteristically low but highly aggregated density for much of their breeding season and over much of their range. The probability of encounter between the sexes of randomly dispersed screwworms, in the absence of a specific, long-range mechanism of attraction, must surely be very low. No such mechanism has been demonstrated, to my knowledge, among the Diptera. The principal cue initiating sexual activity, in many Diptera, is movement. Pheromones enabling sexual recognition over very short distances or upon contact have been demonstrated in the house fly and in a tsetse fly (Langley et al., 1975).

Male aggregations seem an altogether common phenomenon in many species of calyptrate flies, and are held to function as mating assemblies (see Downes, 1969 for review). The characteristic poses, territoriality, short, frequent flights among screwworms and their interactions with other flies differ little from that described for *Gasterophilus* sp. (Walton, 1930), the face fly, *Musca autumnalis* DeGeer (Teskey, 1969), several species of Cuterebridae (Catts, 1967; Hunter and Webster, 1973), *Oestromyia* sp. (Grunin, 1958), *Sarcophaga* sp. (Thomas, 1950), three species of Tachinidae and an anthomyiid fly (Lederhouse et al., 1976). Species of Syrphidae, Tabanidae, Tachinidae, Sarcophagidae, Calliphoridae, Muscidae, and Larvaevoridae have been observed in localized aggregations by Chapman (1954) and by Dodge and Seago (1954).

The significance of the present observations to sterile fly release operations is clear. The efficiency of the sterile male release method will be enhanced by maximizing the chances of putting sterile screwworms into actual or potential breeding sites. Numerous mark, release, and recapture studies on sterilized screwworm flies have demonstrated the extraordinary dispersal potential of females (Hightower et al., 1965). There is, however, no evidence at all to support the contention that released males disperse in this way.

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Department of Entomology, Iowa State University, Ames, Iowa 50011 (formerly: Veterinary Services, APHIS, USDA, Mission, Texas 78572).

Footnotes

[1] This practice was discontinued in early 1977. Small fly containers and narrow swaths (~2 km) are now used. (See Krafsur, E. S., and L. Garcia. 1977. J. Med. Entomol. 14(6):687–697.)

[2] Made explicit by Bushland, R. C. 1975. Bull. Entomol. Soc. Am. 21:23–26.

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REVIEW OF THE DERMESTID BEETLE GENUS *CACCOLEPTUS* WITH DESCRIPTION OF A NEW SPECIES FROM COLOMBIA (COLEOPTERA)

R. S. Beal, Jr.

Abstract.—Adult and larval stages of *Caccoleptus wicki,* new species from Colombia, are described. A key is provided for the three species in the genus. The known geographic range of *C. anisotomoides* Sharp is extended from Honduras to Panamá.

Larvae and adults of an undescribed species within the dermestid beetle genus *Caccoleptus* have been found in northern Colombia preying on eggs and first-instar larvae of *Opsiphanes cassina* F., a nymphalid butterfly defoliator of banana plants. Because of the potential economic value of the species in biological control, it is important to name and describe it. No less important is the opportunity to restudy this little-known genus with a view to gaining a better understanding of its place in the family Dermestidae and of increasing our knowledge of the biology of the family.

The genus was described by David Sharp in 1902. No one appears to have worked on the genus since the appearance of Sharp's original study.

Recognition

Adult members of the genus may be recognized as dermestids by their compact shape, the small, deflexed head which is retracted into the prothorax, the presence of a median ocellus, and the shape of the hind coxa, which is grooved for the reception of the femur. Members of the genus, which falls within the tribe Megatomini (adopting the classification of Zhantiev, 1976), are easily distinguished from most other dermestids by their rotund shape, which gives them an appearance of tiny coccinellids. Other characters which appear to separate adults from other genera of the Megatomini are the following: The male antenna (observed only in *C. rotundus* Sharp) has an 8-segmented club (Fig. 1D); the female antennal club may be 4- or 5-segmented; the pronotum is margined laterally for its entire length, including the anterolateral angle; the antennal fossa occupies all of the hypomeron and is margined along its entire posterior side by a knife-like carina; the prosternum is relatively short with a broad or narrow posterior process; the short mesosternum is completely divided by a groove for the reception of the prosternal process with the pieces on either side of the groove much wider than long (Fig. 1E); the metasternum is strongly convex; the first visible abdominal segment has a single oblique stria on each side originating near the medial edge of the trochanter and extending to the posterior margin of the segment. Sharp's statement that the scutellum is covered by the pronotal lobe is not entirely correct. In each of the species the scutellum is somewhat exposed, although in *C. rotundus* only a very small part of the apex is visible. The metathoracic wing (Fig. 1C) (adopting the terminology of Wallace and Fox, 1975) has a very short $A_{1a} + A_{1b_1}$ (designated as the postcubitus by Beal, 1967, for species of *Megatoma*), an unbranched vein formed from A_{1b_2} (designated as first vannal vein by Beal), and a single vein formed from $A_{1b_3} + A_{1c} + A_2$ (designated as second vannal by Beal). Vein A_3 is absent. Vein A_4 (jugal vein) is very faint, if it is present at all.

The larval stages are known only for *C. wicki.* Mature larvae of this species are easily recognized as belonging to the tribe Megatomini by the presence of hastisetae (spear-headed setae) inserted on the nota and terga. They are readily distinguished from known larvae of all other genera of Megatomini by each of the following characters: (1) the reduced width of the first abdominal segment, which is about 7/9 as wide as either the metathoracic notum or the tergum of abdominal segment 2 (Fig. 2F); (2) the absence of an antecostal suture on any of the nota or terga; (3) the absence of spicisetae on both the anterior part of the abdominal terga (the region that probably should be considered the acrotergite) and along the posterior margin of the terga (Fig. 2F); (4) the elongated shape of the accessory papilla at the apex of the second segment of the antenna (Fig. 2D).

Systematic Position

Both larval and adult characters appear to associate this genus with *Phradonoma* and *Trogoderma.* The fact that in the larvae none of the hastisetae are inserted on the membrane behind any of the abdominal terga but are all inserted on sclerotized areas of the terga places the genus in a group with *Trogoderma*, *Phradonoma*, *Globicornis*, *Megatoma*, and *Reesa.* A specialization found in *Anthrenus*, *Thaumaglossa*, *Cryptorhopalum*, and *Ctesias*, which separates them as a group, is that all have a large cluster of hastisetae inserted on the membrane on each side behind one or more of the abdominal terga. The position of *Caccoleptus* with respect to each genus in the former group is a little less obvious, but it seems to have originated from a stem common to *Phradonoma* and *Trogoderma.* Each of these has the distal group of papillae on the epipharynx enclosed in one or more rings rather than in the center of a callosity (Ford and Kingsolver, 1966). As is true of *Phradonoma tricolor* (Arrow), the distal group of papillae on the epipharynx are divided into a group of four and a group of two papillae and are enclosed in two rather than in a single ring. It also has the setae at the apex of the pretarsus greatly unequal in length in common with most *Trogoderma* rather than equal in length as is true of *Globicornis*, *Megatoma* and *Reesa*. In the case of adults, the shape of the antennal fossa, enclosed behind by a knife-like carina, is characteristic of *Trogoderma*. The 8-segmented club of the male antenna is also much more like *Trogoderma* than like the 1- to 3-segmented club of the latter group. Nonetheless, the specializations found in *Caccoleptus*, particularly in the larval stages, clearly warrant its separation from *Trogoderma*.

Type of the Genus

The type of the genus is *Caccoleptus rotundus* Sharp by original designation.

Key to Species of Adult *Caccoleptus*

1. Integument of elytra dark mahogany brown to piceous with broad ochreous or reddish submedian and subapical bands; submedian band usually with extension along median suture to base. Dorsal pubescence of dark brown to piceous and light golden hairs. Golden hairs on elytra forming broad bands coincident with light maculate areas. Prosternal process broad, as wide as 2× width of front tibia at level of hind margin of front coxa *wicki*, new species
– Dorsal integument immaculate, yellowish brown to mahogany brown. Dorsal pubescence of white hairs and light to dark golden-brown hairs. Elytra transversed by narrow bands of white pubescence. Prosternal process narrow, no wider than front tibia at level of hind margin of front coxa 2
2. White hairs of elytron forming small basal patch, narrow, more or less continuous submedian band, and narrow subapical band; white hairs somewhat ensiform but not more than 1½× as wide as golden-brown hairs *rotundus* Sharp
– White hairs of elytron forming small basal patch near scutellum, subbasal patch near humerus, narrow, interrupted submedian band, narrow interrupted subapical band, and apical patch; white hairs ensiform, about 2× as wide as golden-brown hairs and tending to form clusters with strikingly white appearance *anisotomoides* Sharp

Caccoleptus rotundus Sharp

Caccoleptus rotundus Sharp, 1902:650.

The type-locality for this species is Panamá. An additional male specimen in the U.S. National Museum of Natural History is from El Cermeno, Panamá, July to August, 1941 (J. Zetek). A label on the specimen states that it was collected "ex fruit of *Labatia standleyana* Pittier."

Caccoleptus anisotomoides Sharp

Caccoleptus anisotomoides Sharp, 1902:650.

The type-locality is Rio Hondo, British Honduras. Two female specimens are deposited in the U.S. National Museum of Natural History, one from Panama City, Panamá (no date, E. A. Schwarz), and one from Pedro Miguel, Canal Zone, Panamá, 17 April 1911 (E. A. Schwarz).

Caccoleptus wicki Beal, new species

Adult female.—Habitus as illustrated (Fig. 1A). Dorsal pubescence subrecumbent, bicolorous with light golden and piceous hairs; no ensiform setae present. Head with integument reddish brown on frons, piceous on vertex. Ratio of width across compound eyes to interocular distance 43:26. Punctures of vertex simple, equal in diameter to diameter of facet of compound eye, separated by 1–4× diameter of single puncture. Antenna ochreous with 4-segmented club as illustrated (Fig. 1B). Pronotum with integument reddish; light colored hairs forming transverse subapical band and basal band; punctation of disc similar to that of vertex of head. Elytra with integument piceous with broad median and apical ochreous bands; light colored setae of elytra distributed on light colored bands of integument and in addition forming narrow band along base just posterior to sides of pronotal process and forming line from base along median suture to median band. Ventral surfaces with recumbent, light golden setae; integument of thoracic sterna piceous; integument of abdominal sterna reddish brown with black margin on first 4 sterna. Prosternal process broad (Fig. 1E). Mesosternum strongly transverse (Fig. 1E). Legs ochreous. Ratio of width (measured across humeri) to length (of pronotum and elytra combined) 1:1.39. Length (of pronotum and elytra) 1.66 mm.

Range of observed variations: Color of bands on elytra varying from ochreous to brick red; median band frequently produced anteriad to base and often expanded at base to form short band as wide as pronotal process. Visible abdominal sterna 1–4 usually black with sternum 5 reddish. Ratio of width to length varying from 1:1.35 to 1:1.49. Length ranging from 1.60 mm to 1.82 mm.

Mature larvae.—Color of nota and terga dusky; sterna and legs hyaline. Dorsal spicisetae long, some on lateral margins of nota ⅓ longer than width of notum; hastisetae with apex as illustrated (Fig. 2E); hairs of caudal brush long, some ⅓ longer than body length. Antenna as illustrated (Fig. 2D); segment 1 bearing 1 or no setae; segment 2 without setae; accessory papilla long. Epipharynx (Fig. 2B) with setae of middle setal series at margin equally narrow; lateral setae at margin spatulate, short; distal sensory papillae clustered in 2 margined groups with 4 papillae in an-

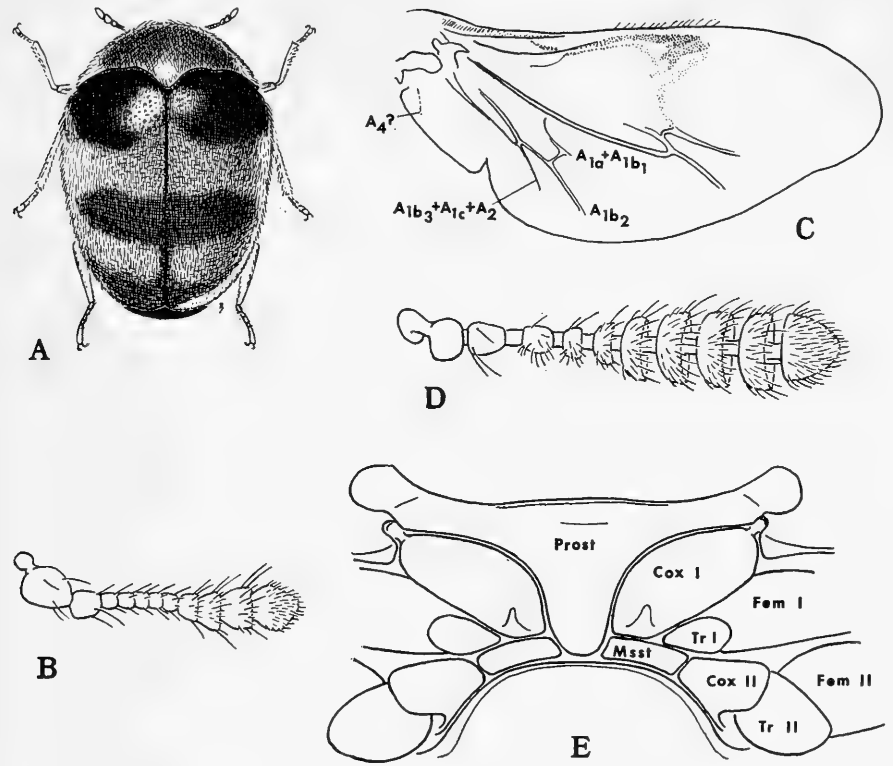

Fig. 1. Adult characters of species of *Caccoleptus*. A, dorsal aspect of *C. wicki*; B, female antenna of *C. wicki*; C, metathoracic wing of *C. wicki*; D, male antenna of *C. rotundus*; E, thoracic sterna of *C. wicki* (Cox = coxa, Fem = femur, Msst = mesosternum, Prost = prosternum, Tr = trochanter).

terior and 2 papillae in posterior group; cluster not enclosed by callosity; 6 sensory cups in proximal row. Maxilla as illustrated (Fig. 2A); terminal segment of palp relatively broad. Labial palp with single seta inserted on ventral side of segment 1, none on segments 2 or 3; 2–3 ensiform setae inserted at apex of each lobe of ligula. Mandible with fringed prostheca and 6–8 lateral setae. Tergum of abdominal segment 1 about 7/9 as wide as metathoracic notum or tergum of abdominal segment 2; antecostal suture lacking (on all nota and terga as well); no spicisetae inserted on acrotergite or on tergite anterior to median row of large spicisetae; no spicisetae inserted along posterior margin of tergum; hastisetae inserted entire width of tergum in row posterior to median row of spicisetae (Fig. 2F). No hastisetae inserted on membrane behind any abdominal tergum (all inserted on sclerotized part of tergum). Tergum of abdominal segment 9 bearing

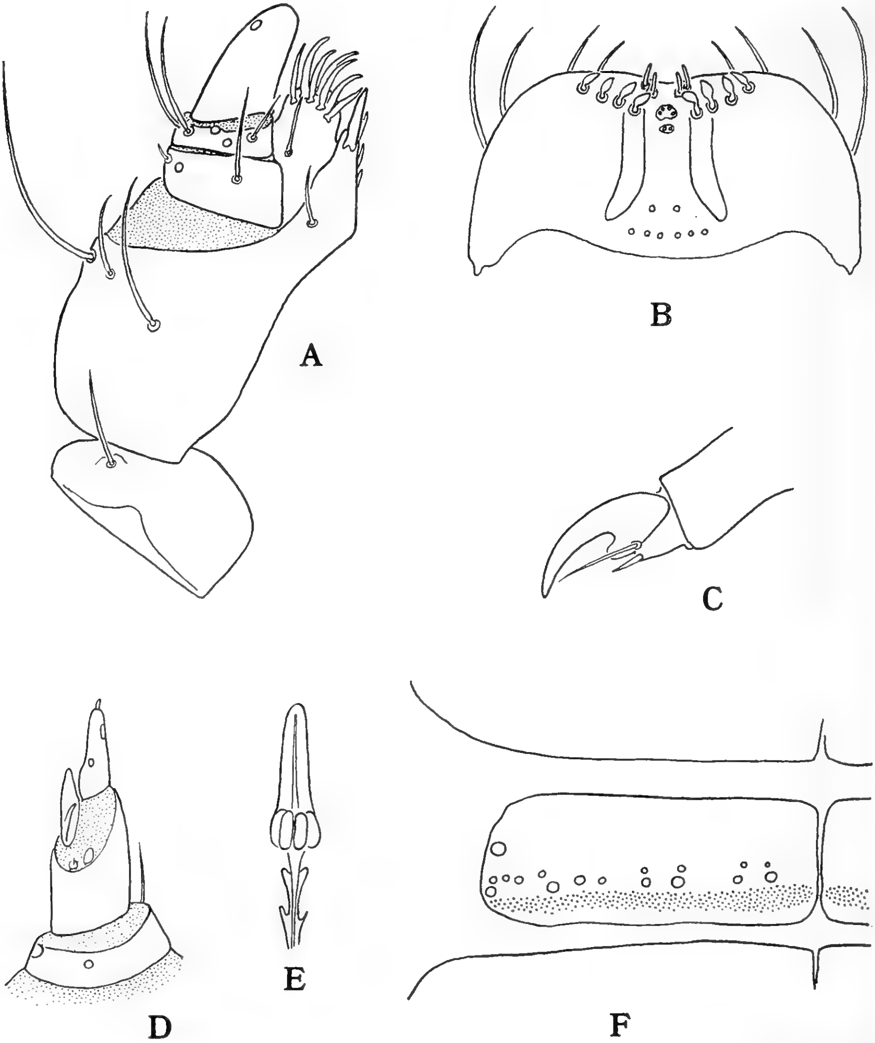

Fig. 2. Larval characters of *C. wicki*. A, maxilla, ventral aspect; B, epipharynx and labral margin; C, pretarsus of mesothoracic leg; D, antenna; E, head of hastiseta from tergum of abdominal segment 2; F, left half of tergum of abdominal segment 1 showing size relative to widths of metathoracic notum and tergum of abdominal segment 2 (circles represent sockets for insertion of spicisetae, size of the socket roughly proportional to size of seta; dots represent points of insertion of hastisetae).

long spicisetae forming terminal brush. Pretarsus as illustrated (Fig. 2C); anterior terminal seta 2× as long as posterior.

Pupa.—Abdominal segments lacking gin-traps.

Holotype ♀ and 13 ♀ paratypes.—El Zulia (10 kilometers northwest of Cúcuta), Santander del Norte, Colombia, 2 July 1976 (A. López).

Other paratypes.—1♀, Botanical Gardens, Georgetown, British Guiana, 26 September 1918 (Harold Morrison); 1♀, Barro Colorado Island, Canal Zone, Panamá, April–May, 1942. Holotype deposited in the collection of the U.S. National Museum of Natural History. Paratypes deposited in the collections of the U.S. National Museum of Natural History, the British Museum (Natural History), the Natural History Museum, Los Angeles County, the California Academy of Sciences, and the collection of the author.

The color of the integument and setal characters given in the key readily separate adults of this species from the two previously described species in the genus. In addition, the single male of *C. rotundus* available for study has unusually prominent compound eyes. Whether this is a sexual character common to males of all species (assuming there are males of *C. anisotomoides* and *C. wicki*) or a distinguishing character of *C. rotundus* is not known.

At the present, no males are known for *C. wicki* or *C. anisotomoides.* This seems a little unusual, since a moderate series of *C. wicki* has been collected. It suggests the possibility that *C. wicki* may reproduce parthenogenetically, a trait found in the somewhat closely related genus *Reesa.*

Etymology.—This species is named for Dr. J. R. Wick, Chairman of the Department of Biological Sciences, Northern Arizona University, in recognition of his faithful and effective leadership in the field of biological education.

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Sumario

Adultos y larvas de una especie nueva de los alrededores de Cúcuta, Colombia, llamada *Caccoleptus wicki,* se han encontrado atacando huevos y larvas de *Opsiphanes cassina* F. en la primera etapa de su desarrollo post-embrionario. Como es sabido este es un en la defoliación del bananero. La especie se diferencia de *C. rotundus* y *C. anisotomoides* por la presencia

en el integumento del élitro de franjas submedianas y subapicales ligeramente coloreadas. En las otras dos especies de *Caccoleptus*, las franjas del élitro están formadas por pelos ligeramente coloreados pero el integumento permanece inmaculado. La larva de *C. wicki* se puede diferenciar de la larva de otro género de Megatomini por la anchura reducida del primer tergo abdominal y por la alargada papila complementaria del segundo segmento de la antena.

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Northern Arizona University, Flagstaff, Arizona 86011.

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ETHOLOGY OF *CEROTAINIA ALBIPILOSA* CURRAN (DIPTERA: ASILIDAE) IN MARYLAND: COURTSHIP, MATING AND OVIPOSITION[1]

Aubrey G. Scarbrough

Abstract.—Male *Cerotainia albipilosa* (Curran) exhibit a complex aerial courtship in front of perched females. The position of the male in flight and subsequent behaviors are discussed. Most courtship flights by males fail to terminate in mating. Males mount females following a rear or frontal flight approach. Non-receptive females display agonistically toward courting males. The mating position consists of male over female and lasts for an average 11.5 minutes. Unlike many asilid species, mating pairs do not fly *in copulo*. Females initiate separation of mating pairs. Most courtship flights and matings occur between 2:00 and 5:00 PM. The egg chorion is bright amber in color and oval in shape; one averaging 0.25 and 0.29 mm in width and length, respectively. Elevated ridges occur on the surface of the chorion except in the immediate area surrounding the micropyle.

Several workers have contributed significant information on the basic reproductive habits of asilid flies (Poulton, 1906; Melin, 1923; Richards, 1929; Bromley, 1933; Wilcox and Martin, 1936; Hull, 1942; Dennis and Lavigne, 1975, 1976; Lavallee, 1970; Lavigne, 1963, 1964, 1968, 1970a, 1970b, 1971, 1972; Lavigne and Dennis, 1975; Lavigne and Holland, 1969; Lavigne et al., 1976; Lehr, 1970; Musso, 1972; Alcock, 1977). Many of the asilid species reported in these studies displayed specific patterns of premating behavior. For many species, premating behavior consisted of short rapid flights in which males searched for receptive females. Matings, following these flights, were initiated either in the air or on substrates. Those initiated in the air began when males overtook females in flight. Following a brief struggle, the pair fell to the substrate where copulation ensued. Those initiated on substrates began when a male landed on a perched female nearby. In the former, the male landed on the female's dorsum, faced the same direction as the female, clasped her genitalia, and assumed a copulation position. In the latter, the male quickly mounted the perched female from the side or rear. In both examples, a brief struggle sometimes preceded genital contact.

Courtship behavior has been observed in some species of at least eleven asilid genera (*Heteropogon, Promachus, Diogmites, Stichopogon, Holopogon, Dioctria, Stelidopogon, Cyrtopogon, Proctacanthella, Proctacanthus, Ablautus*). Courtship behavior involved a hover flight in most species, although leg extension was sometimes included when the male approached a potential mate. Males of five species (*Cyrtopogon glarealis* Melander, *C. auratus* Cole, *C. montanus* Loew, *C. marginalis* Loew and *Ablautus rufotibialis* Back) performed courtship behavior, which also included leg extension, on substrates in front of perched females. Matings were initiated when males landed on the female's dorsum or mounted them from substrates.

Mating positions are usually 'tail to tail' or 'male over female' although some species may show slight modifications of either position.

Oviposition habits of females are variable, depending on specializations of their genitalia. In many species, the posterior segments of the abdomen are modified into slender structures for inserting eggs between and below substrates; in others a circlet of spines is present on the 9th abdominal tergite and is used for digging and covering eggs with soil. Still in other species, neither specialization is present; and presumably they drop their eggs in flight or place them on surfaces or inside fissures in plants or decaying wood.

Methods and Procedures

Extensive field observations of *Cerotainia albipilosa* Curran were made at the Loch Raven Watershed in Baltimore County, Maryland. General methods and procedures for observations made in the field were described earlier (Scarbrough and Norden, 1977). Field observations were recorded on tape and later transcribed into a notebook. Photographic records of various behaviors were taken whenever possible. A Yashica movie camera with a zoom lens was used to record complex behaviors such as courtship oscillations, attempted mountings and agonistic displays. The movies were analyzed to obtain a more accurate understanding of these behaviors.

Results and Discussion

Courtship and mating.—Courtship flights performed by *Cerotainia albipilosa* males involved aerial displays conducted in front of females resting on sunlit perches. Most courtship flights occurred in mid- to late afternoon (Scarbrough and Norden, 1977). At this time females selected perches which ranged from 5 cm to 6 m above ground. However most females (85.1%, *N* = 2,151) were concentrated on perches situated below 3 m.

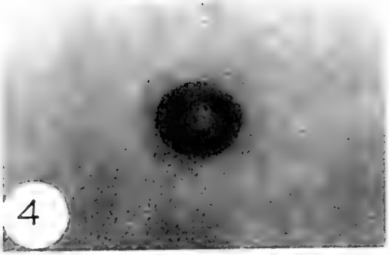
→

Figs. 1–4. 1. Typical positions of a male and female resting on a perch prior to a courtship flight. The female is at the tip of the leaf; 2. Typical posture of a non-receptive female following an attempted mounting by a male. Note the positions of the wings, hind legs and arched abdomen; 3. Typical mating position of *Cerotainia albipilosa*; 4. Egg of *Cerotainia albipilosa* (100×).

1

2

3



4

Males rested on and launched courtships from various plant perches located 1–6 cm behind and 1–2 cm above or below perched females. A male sometimes occupied the same perch on which the female rested (Fig. 1).

While enroute to the courtship position, the male usually flew several cm above or below the perched female to a position about 7–10 cm in front of her. Upon arriving at the latter position, he rotated his body 180° while hovering and faced the female. When the male's flight path was to one side of and at the level of the female, she invariably flew toward him as if he were potential prey, but she turned away before making contact with him. Both sexes usually returned to their perches before the male resumed courtship flights.

In the courtship position, male *C. albipilosa* employed hover flights with leg extensions when approaching a perched female. From this hover position, males oscillated slowly forward and rearward 3–7 cm in front of females before attempting to mount them. During the forward phase, the male's fore legs were elevated to the sides of its head and extended toward the female. The midlegs were directed below the body, and the hind legs extended ventrolaterally and formed an angle of 45–60° from the body. The male hesitated in the forward phase about 3 cm in front of the female and palpated his front tarsi. During the rearward phase, his fore legs dropped below his eyes, and mid- and hind legs remained in one of the previously described positions. The duration of an oscillation averaged 4 s but ranged from 1–12. The average number of oscillations per courtship flight was 5 but ranged from 1–9. Males usually rested on perches near females between courtship flights.

Frequently during an oscillation, a male quickly retreated backward to a position about 15 cm in front of the perched female and then darted forward touching the female's head, thorax and/or wing bases. However, in some cases the male stopped his forward progress just prior to reaching the female only to retreat again. He sometimes did this 2 or 3 times before touching the female. The male's mid- and hind legs were drawn up below his body when he touched the female with the extended fore tarsi. Darting flights were usually preceded by 2 or more forward oscillations and occurred prior to the male's attempt to mount a female.

During courtship, males of *Heteropogon* spp. (Lavigne and Holland, 1969; Lavigne, 1970b; Lehr, 1970; Alcock, 1977), *Cyrtopogon* spp. (Wilcox and Martin, 1936; Lavigne, 1970a; Lavallee, 1970), *Holopogon albipilosa* Curran (Dennis and Lavigne, 1975), *Ablautus rufotibialis* (Lavigne, 1972) and *Stichopogon trifasciatus* (Say) (Lavigne and Holland, 1969) approach prospective mates with leg extension in a similar manner as that performed by male *Cerotainia albipilosa.* With the exception of *C. willistoni* (Curran), males of the above species also move forward and touch females with their fore tarsi. The tarsi and tibiae of all legs of *C. albipilosa* are covered with silvery-white hairs. Parts of the fore tarsi of males of the above species, with the exceptions of *Holopogon albipilosa* and *Stichopogon trifasciatus*, are ornamented with white hairs. Dorsal patches of white hairs are also on the middle tibiae of *Heteropogon maculinervis* James; and all legs of *Stichopogon trifasciatus* are pollinose, with short appressed silvery hairs. The position and movement of the ornamented fore and midlegs and subsequent contact of the female with the male's fore tarsi undoubtedly serve as visual and tactile stimuli which convey conspecific information to females (Lavallee, 1970; Lavigne and Holland, 1969; Alcock, 1977).

Males of *Heteropogon lautus* Loew (Bromley, 1933) and *Stichopogon trifasciatus* (Lavigne and Holland, 1969) include a lateral movement during the courtship hover. Soon after assuming a courtship position or following a rearward phase of an oscillation, *Cerotainia albipilosa* males hovered for about 1–5 s before resuming forward movements. At this stage they sometimes moved 1–2 cm to the right or left of the females. These lateral movements appeared to be primarily associated with sudden changes in wind speeds and shifts of their bodies produced by normal wing movements. Lateral movements were more apparent on windy than on calm days.

Non-receptive females of *C. albipilosa*, like *Heteropogon stonei* Wilcox (Alcock, 1977), responded to oscillating males by moving parts of their bodies singly or in combination and/or flying after males. As a male moved toward a female, she spread her wings laterally so that the wings formed an angle to her body of 50–60°; she frequently vibrated her wings and tilted her body forward. Her abdomen was sometimes vibrated up and down, although it was usually elevated and held in a stationary position above the perch at an angle of 30–40°. She sometimes extended her fore legs and 'waved' her tarsi in a boxing motion toward the male. When a male touched a female's dorsum, the female rocked forward, vibrated her wings and lowered her abdomen. If a male attempted to mount, a female elevated her wings and hind legs above her body and curved the tip of her abdomen down against the perch. She then vibrated her wings and kicked her hind legs at the male (Fig. 2). Females responded to lateral movements of males by pivoting on their midtarsi and shifting their bodies to face them. Frequently females flew from these crouched or tilted positions to chase males or to forage for prey. Females forage when they are non-receptive (Scarbrough, 1978). It is assumed that these movements and subsequent postures of *Cerotainia albipilosa* females provided the primary means of communicating non-receptivity to males and, at the same time, placed them in the normal position from which to fly.

Males usually courted a single female for 20 or more minutes, but periods ranged from 0–204. Zero periods represent those instances when searching males were immediately chased away upon arriving at the site by non-receptive females or other courting males. During this period a male often courted a female several times ($\bar{x} = 6/5$ min interval; $R = 1$–10) with brief interruptions for attempted mountings and perchings. While courtship flights took place during most of the diurnal activity period, most flights occurred from 2:00–5:00 PM. Air temperatures at courtship heights ranged from 22–34°C.

Searching *C. albipilosa* males sometimes appeared to court other Diptera and the ends of twigs. Other asilid species (*Holcocephala abdominalis* (Say), *H. clava* (Loew), *Holopogon phaenotus* (Loew)), syrphids (*Allograpta* spp.) and tephritids (*Rhagoletis* sp.) were abundant, occupied perches during the day near female *Cerotainia albipilosa*, and were courted frequently by males. Larger flies, such as *Musca domestica* L. (Muscidae) and *Sarcophaga* spp. (Sarcophagidae), were less abundant and were courted less frequently. Asilids and syrphids were alarmed by this attention, and males usually remained with and courted them from 1–2 min. The remaining dipterans were easily disturbed and flew away almost immediately. No mounting attempts were observed. Additionally, males frequently courted perched males of the same species, and on occasion, the ends of dead twigs. These courtships were brief, usually consisting of one or two oscillations. Thus it is assumed that searching males cannot recognize conspecifics until the proper responses are performed.

Most courtship flights by male *Cerotainia albipilosa* failed to terminate in matings. This is true of several asilid species exhibiting aerial displays (Lavigne and Holland, 1969; Lavigne, 1970a, 1970b; Dennis and Lavigne, 1975; Lehr, 1970). During over 400 hours of observing courting males, only 38 successful mountings and subsequent matings were observed. Mountings of females were accomplished from a frontal or rear approach. From a frontal approach, a male flew to the usual courting position in front of a perched female. He then flew directly to a position about 2 cm above her; and while hovering, he rotated his body 180° to be in line with hers. Upon landing, the male grasped her wings and abdomen with his legs. The end of his abdomen looped downward, between his legs and over the end of her abdomen. The male's claspers grasped the female's genitalia and union was accomplished. From a rear approach, a male flew directly from its perch behind the female, landed on her dorsum and grasped her in the above manner. Prior to both approaches, males courted females several times before attempting to mount them. When males were unsuccessful in mounting, they flew to perches behind females before resuming courtship flights.

Because of the limited number of complete matings (38) observed and the speed at which the observed ones occurred, it was not possible to ascertain what signal(s) was (were) emitted by the female to indicate acceptance. The only detectable response produced by females was the elevation of the ends of their abdomens prior to union of the genitalia of the sexes. Perhaps receptivity is signaled indirectly by the absence of agonistic behavior toward males attempting to mount. Females which were totally non-receptive flew after and chased males away as soon as they assumed a courtship position. In other cases, females tolerated courting males for several minutes before chasing them away. One male oscillated 37 times in front of a female during a 15 min period (1:03–1:18 PM), while touching her only 6 times. The female appeared to ignore the male during much of the courting period (23 min), although sometimes she spread her wings and vibrated them and her abdomen when he approached her. She also foraged 3 times and fed on one prey during the courtship. The female chased him 4 times before he departed the area. In contrast, another male oscillated 42 times during a 15 min period (2:12–2:27 PM) while darting forward and touching the female 28 times. The female also foraged 5 times and fed on 2 prey during this period but displayed her wings only once and did not chase the male. The pair mated at 2:33 PM. Thus it seems plausible that non-receptivity in females exists at various levels and may be influenced with appropriate internal (satiation) and external (courting males) stimulation.

While mating pairs were observed from 12:06–5:10 PM, the majority (88%) took place between 2:00 and 5:00 PM. Most pairs were found on sunlit upper surfaces of perches at heights ranging from 30 cm up to about 7 m above ground. When temperatures exceeded 34°C pairs moved to the shaded margins of or below leaves. Air temperatures ranged from 25–38°C at heights where mating pairs were observed.

Males usually attempted to mount females from a frontal approach during courtship. Most of the successful (73.6%; $N = 38$) and unsuccessful (70.9%; $N = 2{,}261$) mountings were initiated following oscillations in front of females. The remaining successful (26.4%; $N = 38$) and unsuccessful (29.1%; $N = 2{,}261$) rear mountings were directed from perches and excluded an oscillatory or hover flight. In each case, the male courted the female for several minutes prior to perching and subsequent mounting or attempted mounting. Seven of the successful and 223 of the unsuccessful rear mountings occurred immediately after females returned to perches following various flight activities. Males which had been courting females followed them in flight and mounted or attempted to mount them as soon as they landed, without assuming a courtship position. If females were receptive and received appropriate stimulation, they allowed males to mount from either frontal or rear approach. However, the position assumed by courting males in front of a female probably functioned as an orientation mechanism for the sexes. Thus males were in an effective position from which to recognize conspecifics, to convey species specific information and to mount females.

Male courtship flights and female flight activities frequently attracted other males to the female's perch. It was not unusual to find 2 or 3 males simultaneously attempting to court a single female. This situation occurred several times when a single male courted a female for long periods (>25 min). These situations were brief since the resident male soon began to attack the intruders. The attacks consisted of two males meeting in midair and flying in a tight downward directed spiral. The flights usually terminated a few cm above the ground although a few pairs crashed into shrubs or high grass. Resident males sometimes rammed or grappled with intruders in air while falling to the ground. Physical damage to the flies was not detected. The males also produced a high-pitched, audible buzz during these encounters. The resident male usually remained in the area and courted the female.

Most mating pairs (95.9%; $N = 222$) of *C. albipilosa* took the 'male over female' position (Fig. 3), although a few pairs (4.1%; $N = 222$) were found clinging to margins of leaves or twigs in a chain position. In the latter position, both sexes were holding onto the perch, and their bodies formed variable angles, ranging from 55–95°.

Mating pairs remained at the original female perch sites until the sexes separated. The average duration of 38 complete matings was 11.5 minutes ($R = 10$–15). Partial mating durations of 184 pairs ranged from 5–18 minutes. Females usually initiated separation by slowly pushing alternately with their hind tarsi at the mounted males. Continued pushing eventually dislodged males from their dorsal positions. Still connected by their genitalia to females, males fell backward and assumed a head down position with their dorsal surfaces facing the same direction as the female's head. In this position females began to vigorously kick at males with both tarsi, simultaneously. The males responded by either immediately separating from the females in the suspended position or crawling to a position on a perch beside the females before separating. Times of normal separations (female leg kicking and genital disengagement) ranged from 6–20 seconds. In some cases males released females without the usual tarsal probing. Approach of a predator (*Vespula* sp.) was also sufficient to stimulate males to loosen their grasps of females and fly away.

Upon separation, members of a mating pair reinitiated behaviors which were interrupted by mating. Males usually flew from the area, although some remained and courted the same female or others nearby. Females sometimes flew to another perch, but they usually remained at the mating site where they foraged and fed and/or were courted again.

Females sometimes mated several times during the flight season. Marked females were observed at 15 min intervals/h from 2:00–5:00 PM during a 7 day period (11–18.VIII.76). These observations showed that of 40 marked females, 20% mated each day, 10% mated more than once per day and 5% were not observed mating. In one case a female mated with the same male twice. The male began to court the female immediately after the first meeting. He courted her for 16 min before mating the second time.

Unlike many asilid species, *Cerotainia albipilosa* does not fly while *in copulo.* Mating pairs rested on fully exposed sunlit perches in an almost motionless state. Movement was usually restricted to females' maintaining their positions on perches, discouraging intruders or probing at mounted males near the end of mating. Intruder males usually hovered in the courting position in front of mating pairs. Females responded by extending their fore legs and slowly waving their tarsi at the approaching intruders. The intruders then either flew away or landed near mating pairs on perches where they probed the tips of their abdomens toward the female's genitalia and apparently attempted to mate with them. Mating females responded by kicking at them with their hind legs and/or crawling to new positions on perches. Kicking by females and the inability of males to clasp their genitalia was usually sufficient to discourage the intruders. Continued probing by one or more intruding males sometimes induced separation of the mating pair. Similar reactions were elicited when a pair was touched with a pencil. Females waved or kicked their legs at the probing pencil and then crawled away. When captured in vials, mating pairs did not separate until they were vigorously shaken, and females moved only to maintain a balanced position. Mating males usually maintained a thanatosis-like state until they released their grasp on females. Mating males occasionally elevated their wings and vibrated them when exposed to these stimuli. This response appeared to be more a function of maintaining balance than an agonistic display.

According to some investigators (Cloudsley-Thompson, 1961; Poulton, 1906; Hobby, 1931; Musso, 1971), some asilid males may present potential mates with food before mating or court only feeding females. In each case females were momentarily engaged in feeding which permitted a period for males to mate with females and, at the same time, to escape predation from the latter. Evidence to support this suggestion is lacking (Dennis and Lavigne, 1975). Behavior patterns of *C. albipilosa* do not support this suggestion since 1) males court without prey (Scarbrough, 1978), 2) males court both non-feeding and feeding females (only 40% ($N = 596$) of the courted females were feeding), 3) only 7% ($N = 212$) of the mating females were feeding and 4) cannibalism was not observed.

Eggs and oviposition.—Attempts to obtain eggs in the field and from live or decapitated adults placed in vials for oviposition were unsuccessful. Eggs were obtained by dissecting live females in Ringer's Insect Solution. Females to be dissected were taken at random throughout the flight season.

Eggs found in calyces, oviducts and connecting genital chambers were considered to be mature since their chorions were sclerotized and the darkest in color. The number of developed eggs obtained from 30 females ranged from 52–148 with most flies (17) having over 100. In addition, each ovary consisted of about 20 ovarioles which contained 5–8 developing eggs. Six females captured *in copulo* early in the season (5–10.VII.73) and dissected lacked mature eggs, but the ovarioles contained numerous oocytes. Although the number of eggs produced by a single female was not determined, these results indicate that 1) eggs are produced continuously during the female's life, 2) eggs are not mature and ready for fertilization when females emerge, but require a period for maturation and 3) females may mate before eggs are mature.

Sclerotized chorions of mature eggs were uniform in color, shape and size. They were bright amber, slightly oval and averaged 0.25 mm in width and 0.29 mm in length (100 eggs, 10 from 10♀♀) (Fig. 4). The chorion had characteristic elevated ridges forming 4–7-sided rings with 6-sided rings being the most common. Melin (1923) reported similar structures on eggs of *Laphria* spp. and *Dioctria* spp. At one end, the ridges faded away to form a smooth surface which surrounded the micropyle. Other microstructures associated with insect chorions were not visible at 550×.

Oviposition habits of *Cerotainia albipilosa* females are unknown. Only one oviposition was observed during this study. A perched female (13. VII.74; 3:41 PM) lowered its abdomen, touched the tip to the perch and released 3 eggs consecutively. She groomed the tip of the abdomen with her hind legs and flew away. Air temperature at the oviposition site was 31°C. Other females (12) behaved similarly by touching the tips of their abdomens to perches and grooming their abdomens, but eggs were not located. The female's ovipositor is minute and lacks specialization for inserting eggs into substrates. Females of *Dioctria*, *Laphria* (Melin, 1923) and *Andrenosoma* (Musso, 1971), which also lack genital specializations, typically deposit eggs into holes or grooves on substrates or while in flight. Thus *Cerotainia albipilosa* females probably behave similarly by depositing eggs at perches or at specific sites among vegetation in the area where they forage and mate.

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Department of Biology, Towson State University, Baltimore, Maryland 21204.

Footnote

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A NEW SPECIES OF XENOCALIGONELLID MITE FROM THE GALÁPAGOS ISLANDS (ACARI)

Roberto H. González

Abstract.—A new family of prostigmatid mites, the Xenocaligonellidae is erected to include the bizarre genus *Xenocaligonellus* De Leon 1959, which was formerly placed under the Caligonellidae. A new species, *X. galapagus*, is described from the Galápagos Islands off the coast of Ecuador.

De Leon (1959) erected the genus *Xenocaligonellidus* for *X. ovaerialis*, a bizarre species from southern Florida and western Mexico. A major caligonellid character, namely the peritremata entering the stylophore, was taken into consideration for placing this genus in the family Caligonellidae Grandjean, as defined by Summers and Schlinger (1955). However, De Leon, recognizing other major characters which deviate from the family characteristics, created the subfamily Xenocaligonellinae to account for these non true caligonellid characters.

As *Xenocaligonellidus* shares only one major character with the true caligonellids whilst having a number of clear cut differences, a new family status is proposed for these odd looking mites. Reasons supporting this action are ample, viz: *Xenocaligonellidus* lacks an important raphignathoid character—the palptibial claw. In addition, non caligonellid characters include: Coxae contiguous, not separated in groups I–II and III–IV; anal slit distinctly ventral and contiguous with the genital opening; and empodium with a double row of multiple capitate hairs. The general body shape and the outstanding development of most of the dorsal setae are further characters which make it possible to define a new family, the Xenocaligonellidae.

From a phenotypic standpoint, xenocaligonellid mites are remarkably different than all known species in the families of Raphignathoidea. The arrangement and quality of dorsal setation, the absence of the paraaxial claw on palptibiae, the lack of transverse fisures on dorsal idiosoma, and the tetranychid kind of empodial arrangement make those mites to be an extremely marginal raphignathoid group. The placement of the new family under this group has reluctantly been made as there is no other superfamily providing for such assorted combination of distinct characters. On the other hand, the distinctly looped peritrematal arrangement would suggest that this family is an offshoot of the Caligonellidae.

Xenocaligonellidae, new family status

Small, flattened mites, with cheliceral bases fused into a stylophore bearing a chambered, loop-shaped peritremata. Gnathosoma exposed from above. Palpi 5-joined, tibia lacking distal claw, palptarsus longer than tibia, with a set of stubby distal setae. One pair of flagellate ventral setae on subcapitulum. Dorsal setae on idiosoma whiplike, some of them longer than body; other setae acicular, distally spinose. Eyes, two pairs. Coxae II–III contiguous. Anal slit and genital opening contiguous on the ventral side. Legs short, robust with a blade shaped empodia bearing two rows of multiple capitate hairs.

As De Leon stated for *X. ovaerialis*, males and nymphs resemble the female except for the reduction in dorsal setae numbers. Larvae have fewer pairs of dorsal setae, and the caudalmost pair of anal setae are much longer than other dorsals.

The habits of this family are known for *X. ovaerialis* only. De Leon reported this species to occur on *Quercus*, *Persea*, *Celtis*, *Inga* and several unidentified plants. An interesting characteristic of *Xenocaligonellidus* is the egg-laying habit. They are attached to the distal end of an erect stalk, a feature known in insects apparently to avoid egg predation. With the finding of a second species from the neotropical region, the generic characteristics have been better understood and amended accordingly.

Xenocaligonellidus De Leon 1959, emend.

Description.—Idiosoma circular, flattened, with smooth integument; stylophore broadly triangular, fused along the midline except at the distal ⅓; peritremata Ω-shaped, without a distinct distal opening. Movable digits styletlike. Fixed digits finely pointed. No terminal claw on palptibia. Palptarsus longer than palptibia with a crown of stubby, straight setae. Two pairs of eyes. One single pair of ventral subcapitular setae. Fifteen pairs of dorsal setae distributed as follows: 5 pairs of propodosomal setae; 10 pairs of hysterosomals. Coxae contiguous, longer than respective femora, without coxal plates. Legs short, with genua and tibia of about equal size. Ambulacra with strong claws and a bladelike empodia bearing 2 rows of multiple, capitate hairs. Anal slit contiguous to the ventral vaginal opening, guarded posteriorly by 2 pairs of thick, barbed, long setae.

Type-species.—*Xenocaligonellidus ovaerialis* De Leon 1959, by original designation.

Terminology.—For descriptive purposes, idiosomal dorsal setae are separated into propodosomals and hysterosomals. There are 5 pairs of whiplike propodosomal setae, the posteriormost pair termed central propodosomal (*cp*). The hysterosomals include 1 pair of humerals (*h*), 2 pairs of laterals (L_1, L_2), 2 pairs of sublaterals (S_1, S_2) and 5 pairs of dorsocentrals (*dc*) (Fig. 1). The homology of L_1 to the acicular setae of the dorsocentral series and that of L_2 to the sublateral pairs suggest that these lateral setae, apart from their marginal position, share no functional characters in common.

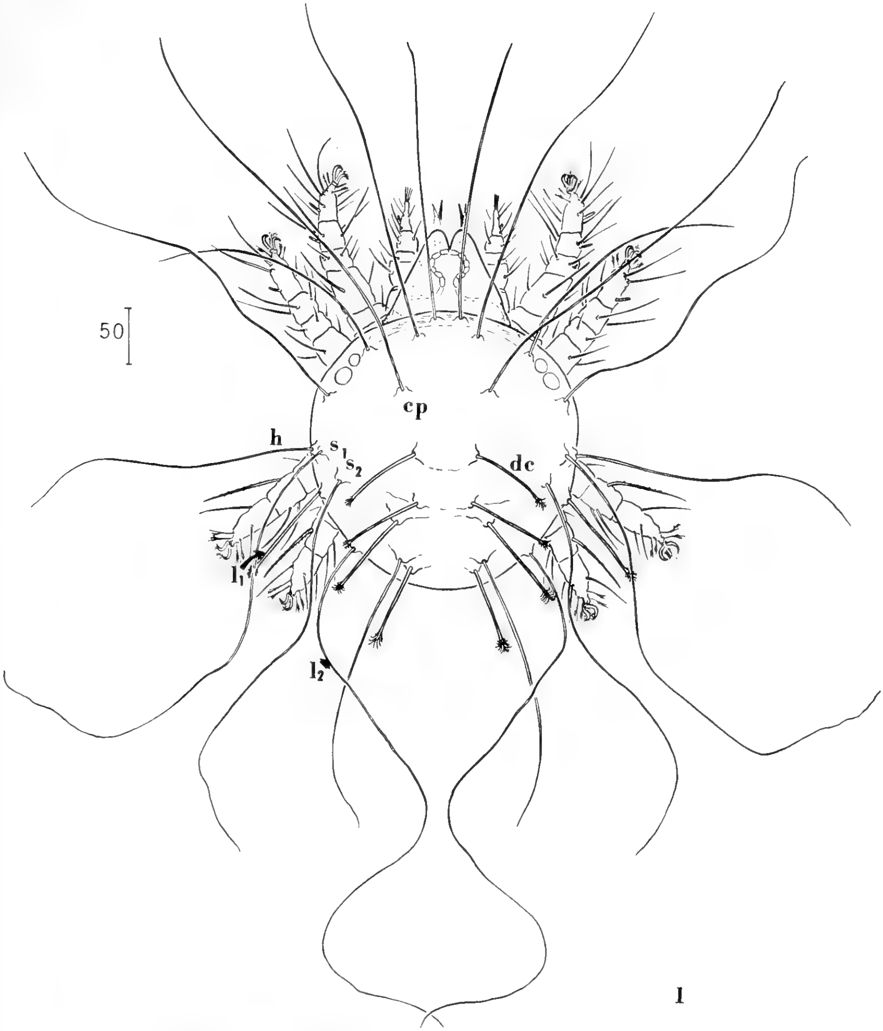

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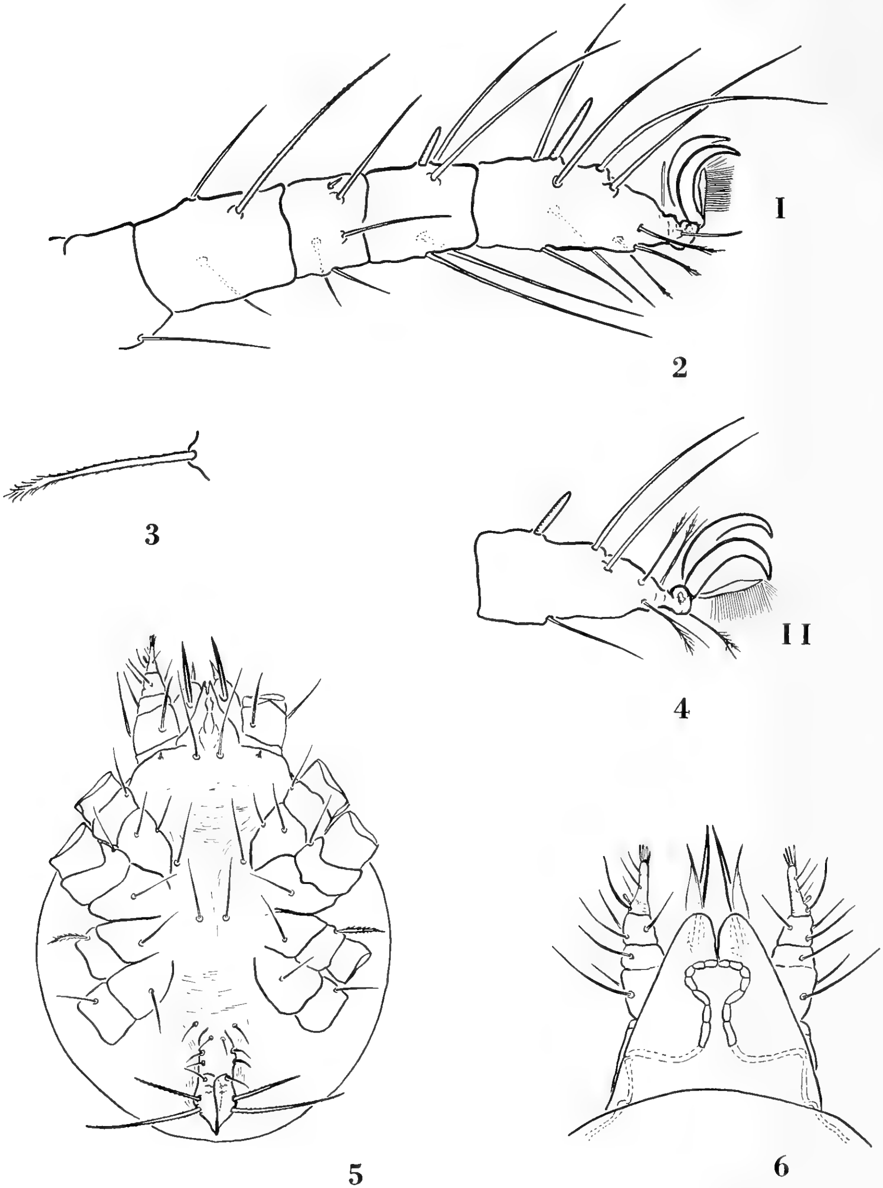
Fig. 1. *Xenocaligonellus galapagus*, dorsum of female. Setae: *cp* central propodosomals; *h* humerals; s_1–s_2 sublaterals; l_1–l_2 laterals; *dc* dorsocentrals.

All measurements are given in microns; length of dorsal whiplike setae are rounded to the nearest 5 microns.

Xenocaligonellidus galapagus González, new species

A species with circular, flattened, idiosoma and a combination of acicular and whiplike dorsal setae; posterolateral setae L_2 the longest of dorsal series,



Figs. 2–6. Female. 2. Leg I; 3. Dorsal acicular seta; 4. Tarsus leg II; 5. Ventral aspect; 6. Stylophore with looped peritremes, and palpi.

nearly 2.4× longer than diameter of body. Posteriormost 2 pairs of anal setae, acicular, stub.

Female.—Idiosoma 260 in diameter, leg I, 170; stylophore broadly triangular 132 × 95, deeply notched at the front end. Stylets needle-like, fixed digits finely pointed. Peritremes of caligonellid type, extend to the distal ⅓ of stylophore, loop made up of 14 cells (Fig. 6). Number of setae on palpal segments as follows: Femur 2; genu 1; tibia 3; tarsus 4, in addition to a proximal bulb-shaped sensory rod and 4 stubby terminal sensory setae. Dorsal aspect of idiosoma: 15 pairs of setae borne on strong tubercles. Five pairs of propodosomals, anteriormost pair 222, 2nd pair 360, preoculars 270, postoculars 395, central propodosomals (*cp*) 425. Ten pairs of hysterosomals of which 5 pairs are whiplike, L_2 being the longest of dorsal series, 660; all dorsocentrals but pair 4 and the lateral L_1 are acicular, distally spinose, ranging from 90–95 each (Fig. 3).

Number of setae and special sensoria (in parenthesis) on leg segments I through IV: Coxae 2-1-1-1; trochantera 1-1-1-1; femora 3-3-1-1; genua 3(1)-3-1-1, tibiae 4(1)-4-3-3, tarsi 11(1)-7(1)-7-7. Seta on trochanter III distinctly thickened and barbed (Fig. 5). Genu I carries a spinelike solenidion closely associated with dorsolateral seta; tibia and tarsus I provided with a well-developed corresponding solenidia 8 and 14 respectively (Fig. 2, leg I). Anterolateral setae on tibiae III/IV strongly barbed, 65 and 60 respectively (see Fig. 1). Tarsi II to IV provided with 4 branched terminal setae (Fig. 4, tarsus II).

Ventral side (Fig. 5).—No distinctive plates except for the anal covers. One pair of long, flagellate, subcapitular setae in the maxillicoxal area, mesal to a short, spinelike seta behind palpal bases. Coxal areas I–IV contiguous; 2 pairs of anteroventral setae and 1 pair of paragenitals close to genital group. Three pairs of subequal genital setae and 3 pairs of anals; the last 2 pairs of anals distinctly needle-like, barbed, and longer than anogenital slit measuring 50 and 88 respectively.

Holotype.—Collected on unknown plant, Wenman Island, Galápagos Arch., 31 January 1964 (D. Q. Cavagnaro). Deposited in Acarology Collection, Faculty of Agronomy, University of Chile, Santiago.

Remarks.—The two known species of *Xenocaligonellus* can be separated on the basis of the length of dorsal and ventral setae relative to the body size and in the quality of anal setae. *Xenocaligonellus galapagus* has longer whiplike setae, uniformly long acicular setae and two thick barbed posteriormost anal setae longer than the anogenital slit. *Xenocaligonellus ovaerialis* has one anal seta of this kind only. In addition, genu II of *galapagus* bears three setae instead of two and acicular seta (L_1) is marginal, not sublateral, in position.

Resumen

Una nueva familia de ácaros prostigmatos, Xenocaligonellidae, se ha creado para el género *Xenocaligonellus* De Leon 1959, el cual originalmente se ubicó en la familia Caligonellidae. Se describe una nueva especie, *X. galapagus* González, colectada en las islas Galápagos en las costas del Ecuador.

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BIOLOGY OF A NEOTROPICAL SNAIL-KILLING FLY, *SEPEDONEA ISTHMI* (DIPTERA: SCIOMYZIDAE)

Lloyd Knutson and Karl Valley

Abstract.—*Sepedonea isthmi* (Steyskal) is known from the Canal Zone, Panama, Trinidad, Venezuela, Colombia, Bolivia and Brazil. The species is found in various fresh-water situations, where the larvae are obligate predators of pulmonate snails. Females collected in Venezuela in April, Trinidad in May and Colombia in June laid up to 406 eggs each in the laboratory. The incubation period was 2–6 days; the first larval stadium lasted 2–4 days; the second, 3–6; the third, 5–8; and the pupal period was 8–14 days, at room temperatures. Larvae killed and ate as many as 23 aquatic snails ranging in size from 1–6 mm. Prey species included *Biomphalaria glabrata* (Say), *Drepanotrema* (*Fossulorbis*) *depressissimum* Moricand, *D.* (*F.*) *lucidum* Pfeiffer, *Helisoma trivolve* (Say), *Physa venustula* Gould and *Lymnaea* sp. in the laboratory. The morphology of the immature stages of the *Sepedon* Group is discussed; and the egg, all three larval stages and the puparium of *Sepedonea isthmi* are described and figured.

The introduction of *Sepedomerus macropus* (Walker) from Nicaragua into Hawaii in 1958 and 1959 for control of *Lymnaea ollula* Gould[1], the snail host of the cattle liver fluke, *Fasciola gigantica* Cobbold (Chock et al., 1961; Berg, 1973), has shown that it is possible to rear Sciomyzidae in large quantities and that an exotic species can disperse from release sites and build up large and persistent populations. Future use of Sciomyzidae as biological control agents must be based not only on quantitative and experimental field and laboratory studies of critical aspects such as predation and competition, e.g. Eckblad and Berg (1972) and Berg (1973), but also on knowledge of the behavior of many different candidate predator species. Most snails that are important as intermediate hosts of parasitic worms of humans and domestic animals are pulmonate, aquatic and amphibious species in tropical and subtropical regions. *Sepedon* Latreille and related genera are the dominant Sciomyzidae in tropical regions, and the larvae of most reared species are highly specialized predators of aquatic snails. Thus it is of special interest to broaden our knowledge of the basic life cycles of species belonging to these genera.

The fundamental work on the life histories and morphology of immature stages of *Sepedon* and some related genera is the treatment of ten Nearctic, four Neotropical and two Palearctic species by Neff and Berg (1966). The larvae of all species discussed in that paper are predators of fresh-water pulmonate snails. Knutson et al. (1967) described the biology of the first *Sepedon* known to be a parasitoid of terrestrial snails in the genus *Succinea*

Draparnaud, and they added two African species to the list of aquatic predators. Abercrombie (1970) presented extensive biological information on six species of *Sepedonea* Steyskal. Abercrombie and Berg (1975) reported on the biology of *Thecomyia limbata* (Wiedemann), a Neotropical member of the *Sepedon* Group. The present paper treats the biology and immature stages of a Neotropical, aquatic, predaceous species, *Sepedonea isthmi* (Steyskal).

Taxonomy

The genera of Sciomyzidae related to *Sepedon* have been treated as a subtribe, tribe or subfamily by various authors. Steyskal (1973) regarded these genera as forming only a "Group" that is not particularly distinctive from typical Tetanocerini (subfamily Sciomyzinae). Steyskal included the following genera in the "*Sepedon* Group": *Sepedon* Latreille, *Sepedonella* Verbeke, *Sepedoninus* Verbeke, *Thecomyia* Perty, and his new genera *Sepedomerus* and *Sepedonea* (= *Sepedon lindneri* Group of authors). The Neotropical genus *Sepedonea* includes the species discussed herein (*Sepedonea isthmi*), seven other described species (*S. barbosai* Knutson and Bredt, *S. canabravana* Knutson and Bredt, *S. guatemalana* (Steyskal), *S. guianica* (Steyskal), *S. lagoa* (Steyskal), *S. lindneri* (Hendel), and *S. telson* (Steyskal)), and five undescribed species known to us.

Sepedonea can be distinguished from related genera by using the characters given by Steyskal (1973). *Sepedonea isthmi* is distinguished from other *Sepedonea* by the following features: (1) hind femur with apical dark marking but without pre-apical marks, (2) middle femur posteroventrally with 10–12 spinules extending ⅔ distance to base, (3) wing with anterior and posterior crossveins distinctly infumated. The male genitalia also show important specific differences and indicate that *S. isthmi* is most closely related to *S. guianica*. The species of *Sepedonea* were catalogued by Knutson et al. (1976).

Distribution

Sepedonea isthmi has been recorded from the Canal Zone, Panama, Trinidad, Venezuela, Colombia, Bolivia and Brazil. Steyskal (1951) described this species from three specimens from Panamá, Canal Zone, Corazal, 1 March 1912, 1♂ (holotype), No. 60905, USNM, 1♀ (allotype), and Juan Mina, 2 September 1923, 1♂ (paratype), USNM. Also, we have collected or seen the following specimens: BOLIVIA: *Beni*: Rurrenabaque, 175 m., 10–23 October 1956, 1♂, L. E. Peña, CNC. BRAZIL: *Amazonas*: Paraná da Cigana, Parintins, November 1969, 1♂, 1♀, Exp. Perm. Amaz., USNM. *Pará*: Breves, Ilha do Marajó, September 1969, 1♀, Exp. Perm. Amaz., MZUSP. *Goiás*: Rio Preto, 70 km NE Brasilia, 20 km S Formosa, 7 Novem-

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Fig. 1. Collecting sites for *Sepedonea isthmi*.

ber 1974, 1♂, L. Knutson, USNM. *São Paulo*: S. Vicente, Parque Bitaru, 29 May 1967, 1♂, J. Abercrombie and C. O. Berg, CU. Espirito Santo, Itaguaçu, October 1970, P. C. Elias, 1 damaged specimen, MZUSP. COLOMBIA: *Valle*: 1.7 km W Cali Puerto, 11 June 1969, 3♂, 1♀; 14 June 1969, 2♀, K. R. Valley, CU. 5 km SE Cali, near Navarro, 11 June 1969, 2♂, K. R. Valley, CU. 6.5 km SE Cali, Navarro, 11 June 1969, 5♂, 4♀, 14 June 1969, 8♂, 10♀, K. R. Valley, CU. Morga, 20 km SE of University, 22–25 June 1964, 1♀, C. O. Berg, USNM. PANAMÁ: Panamá, La Jagua Hunt Club, about 32 km ENE Balboa, 1 July 1969, 1♀, K. R. Valley, CU. TRINIDAD: Caroni River, 12 October 1918, 1♀, H. Morrison, USNM. Princess Margaret Highway, 0.15 km south of junction with Churchill-Roosevelt Highway, 9 km west of Port of Spain, 4, 5 May 1972, 8♂, 2♀, F. D. Bennett, M. Yaseen, L. Knutson, USNM. VENEZUELA: *Carabobo*: Valle Seco, January 1940, 1♂, P. Anduze, USNM. Valencia, 16 March 1971, 1♀, C. O. Berg, CU. *Aragua*: Pto. de Cata, between Caracas and Puerto Cabello, 17 April 1972, 9♂, 1♀, C. J. Rosales and L. Knutson, USNM. Ocumare de la Costa, 28 km NW Maracay, 14 March 1971, 2♂, C. O. Berg, CU. Embalse de Guataparo, 13 April 1972, 1♂, L. Knutson, USNM. *Cojedes*: Lago Taguanes, near Tinaquilla, 13 April 1972, 3♀, L. Knutson, USNM. La Piedrita, 16 February 1911, 1♀, S. Brown, ANSP. (ANSP = Academy of Natural Sciences, Philadelphia, CNC = Canadian National Collection, CU = Cornell University, MZUSP = Museu de Zoologia, Universidade de São Paulo, USNM = United States National Museum.)

The distribution of *S. isthmi* is shown in Fig. 1. *Sepedonea guianica* has a partially contiguous range.

Biology

Neff and Berg (1966) reared *Sepedonea guatemalana* in Central America, and Abercrombie (1970) reared *S. lagoa*, *S. lindneri*, *S. telson*, and three undescribed species of *Sepedonea*, all from southeastern Brazil and Argentina. The larvae of all of these species are predators of aquatic snails in various fresh-water situations.

Habitats of *S. isthmi* are typical of many Sciomyzidae. Most of the adults that were used to start our rearings were swept from herbaceous vegetation emerging from water about 30 cm deep in an extensive series of roadside borrow pits (Fig. 2) near Port of Spain, Trinidad, on 4 and 5 May 1972. No other Sciomyzidae were collected at that locality, although larvae, pupae, and adults of *Sepedomerus macropus* were taken on 5 May at the edge of nearby Caroni Swamp, San Juan, Trinidad. The only other Sciomyzidae known from Trinidad are *Sepedomerus bipuncticeps trinidadensis* (Steyskal) and an undescribed species of *Thecomyia*.

In Venezuela, adults of *Sepedonea isthmi* and *Sepedomerus bipuncticeps* (Malloch) were swept from weed-choked, roadside ditches at Puerto

Fig. 2. Habitat of *Sepedonea isthmi*, fresh-water marsh, six miles west of Port of Spain, Trinidad, 4 May 1972.

de Cata, between Caracas and Puerto Cabello, on 17 April 1972. Adults of *Sepedonea isthmi*, with those of *S. guianica* and *Sepedomerus bipuncticeps*, were collected at the margin of Lago Taguanes, near Tinaquilla, Venezuela, on 13 April 1972. The single male collected in Goiás, Brazil, was found with *Sepedomerus bipuncticeps*, *Sepedonea barbosai*, and *S. canabravana*. Adults of *S. isthmi* were swept from dense, emergent grasses growing in a wet pasture near Cali, Colombia between 11 and 14 June 1969. Imagines of *S. guianica*, *Sepedomerus bipuncticeps* and *Sepedomerus macropus* were usually taken with *Sepedonea isthmi* in various localities visited in the Cali-area.

Immature stages were collected in Colombia. Nine puparia were found floating in shallow water among shoots of emergent vegetation on 14 June near Cali; three produced adult flies within six days and six each yielded a parasitoid wasp (*Trichopria* sp., Diapriidae) between 20 June and 3 July. A third-instar larva collected on the same date near Cali pupariated, and an adult emerged on 29 June.

Adults collected in Trinidad, Colombia and Venezuela were placed by pairs in small jars (6 × 12 cm) containing a substrate of damp cotton, provisioned with crushed snails and a mixture of powdered milk, honey and brewer's yeast and covered with mesh cloth. A pair of imagines collected on 14 June in Colombia were first observed copulating 10 days later; they mated approximately 30 minutes. Adults collected on 5 May in Trinidad were first seen mating on 16 May, and they continued to mate infrequently until 8 September. Flies collected on 17 April in Venezuela were seen mating on 7 May. Adults that emerged in the laboratory during August did not mate during the following 3 months in the laboratory. The copulatory posture is similar to that of most other Sciomyzidae (male's front tarsi on parafrontal area of female's head, male's middle tarsi on sides of female's thorax, and male's hind tarsi grasping end of female's abdomen).

One female collected in Colombia on 11 June deposited 104 eggs during the following four days; daily egg counts ranged from 26 to 31. A laboratory reared male and female that emerged on 21 July were placed in a breeding container the next day, but the three eggs that the female deposited on 6 August were inviable. Four females were collected in Trinidad on 5 May, and they respectively laid 406 eggs between 16 May and 5 October, 214 between 16 May and 23 August, 30 between 10 May and 6 June and 4 on 12 May. A female collected in Venezuela on 17 April laid 38 eggs between 6 and 25 May. Laboratory reared females from Trinidad did not oviposit.

Eggs were laid side by side in rows of 2–14 on pieces of vegetation or on the dry walls of the breeding jars, but not on shells of crushed or living aquatic snails. The eggs gradually darkened, and the incubation period was 2–6 days at room temperatures (20–22°C).

Larvae killed and ate the aquatic snails *Biomphalaria glabrata* (Say), *Drepanotrema* (*Fossulorbis*) *depressissimum* Moricand, *D.* (*F.*) *lucidum* Pfeiffer, *Helisoma trivolve* (Say), *Physa venustula* Gould and *Lymnaea* sp. during laboratory rearings. *Biomphalaria glabrata* and *Physa* sp. were the dominant aquatic snails at the collecting sites in Trinidad, and *Drepanotrema depressissimum*, *D. lucidum*, and *Physa venustula* were the dominant aquatic snails at the collecting sites in Colombia. None of the larvae fed in egg masses of *Helisoma trivolve*, but a few second-instar larvae penetrated egg masses of *Physa* sp. and ate the embryonic snails.

First-instar larvae preyed upon newly hatched and small snails (1–2 mm in greatest dimension). As the larvae grew in size they attacked larger snails; mature *Helisoma trivolve* were frequently killed by large, third-instar larvae. One larva killed and fed on 22 snails (1–6 mm) during its three stadia; another consumed parts of 23 prey individuals (1–4.2 mm). During their 5-day third stadia, two larvae killed and consumed, respectively, seven and eight snails, measuring 4–6.5 mm. The larvae remained in the shells, consuming relatively fresh tissue, for less than 1 day. They rested under the wet sand or gravel in the rearing containers, with their posterior spiracles exposed above the water surface. Larvae lived a relatively long time without food; three first-instar larvae survived 1–4 days and nine second-instar larvae lived 6–11 days in starvation chambers. The first stadium lasted about 2–4 days; the second, 3–6 days; and the third, about 5–8 days. The larval period ranged from 13–17 days.

Puparia were formed in wet sand, among pebbles of gravel and on the dry undersides of lids of rearing containers; they are obviously adapted for flotation (Fig. 17). Eighteen puparia formed between 29 July and 4 August produced adults 10–13 days later; of 17 puparia formed between 8 and 28 July, 16 produced adults in 8–9 days and one yielded an adult after 14 days. Field collected adults lived up to 78 days in the laboratory.

Morphology of Immature Stages
Sepedon Group

Immature stages of species of the *Sepedon* Group are among the most distinctive in the family, but because less than 10% of the immature stages of acalyptrate Diptera have been described, diagnostic features can be stated only provisionally. The major source of information on the morphology of the immature stages of *Sepedon* and related genera is Neff and Berg's treatment (1966) of 16 species. Knutson et al. (1967) described the immature stages of three African species of *Sepedon*, Nagatomi and Tanaka (1967) provided a thorough description of the egg of *Sepedon sauteri* Hendel, and Abercrombie (1970) characterized the immature stages of six species of *Sepedonea.* Abercrombie and Berg (1975) described the developmental stages of *Thecomyia limbata.*

Although eggs of some species of the *Sepedon* Group are distinctive, there is no single character that distinguishes them reliably from other genera of Sciomyzidae. All described eggs of this group bear a subterminal micropyle, characteristic of all known eggs of the Tetanocerini. Neff and Berg (1966) stated that the coarse longitudinal striations on eggs of reared *Sepedon* are rather distinctive for this genus. The patterns of chorionic sculpturing, color and dimensions have been useful characters for separating eggs of various members of the *Sepedon* Group.

Mature larvae of the aquatic *Sepedon* Group have a tapered, strongly retractile anterior end; truncate posterior end with three or five pairs of fleshy lobes around the spiracular disc; paired posterior spiracles each with three slits and four profusely branched, interspiracular float hairs; frequently a dark, patterned integument with many folds and wrinkles, and hair patches dorsally; wartlike body tubercles with those on the ventral surface functioning as pseudopods; and inconspicuous anterior spiracles.

Larvae of the *Sepedon* Group are further characterized by the following features diagnostic of the cephalopharyngeal skeleton of all reared Sciomyzidae: An unpaired, anteriorly serrate, transverse ventral arch present between the anteroventral margins of the mandibular sclerites, posterior arms of hypostomal sclerite not overlapping the anteroventral process of the pharyngeal sclerites in third instar, ventral cornu without dorsobasal lobe and no oral grooves around the mouth opening or longitudinal ridges in the floor of the pharynx (except subfamily Salticellinae). Also, larvae of the *Sepedon* Group have three to seven accessory teeth on the basal part of the mandibular sclerite, a ventral arch with a relatively deep emargination posteriorly, no dorsal bridge between the pharyngeal sclerites, no window in the dorsal cornu of the pharyngeal sclerites and an indentation index of less than 50.

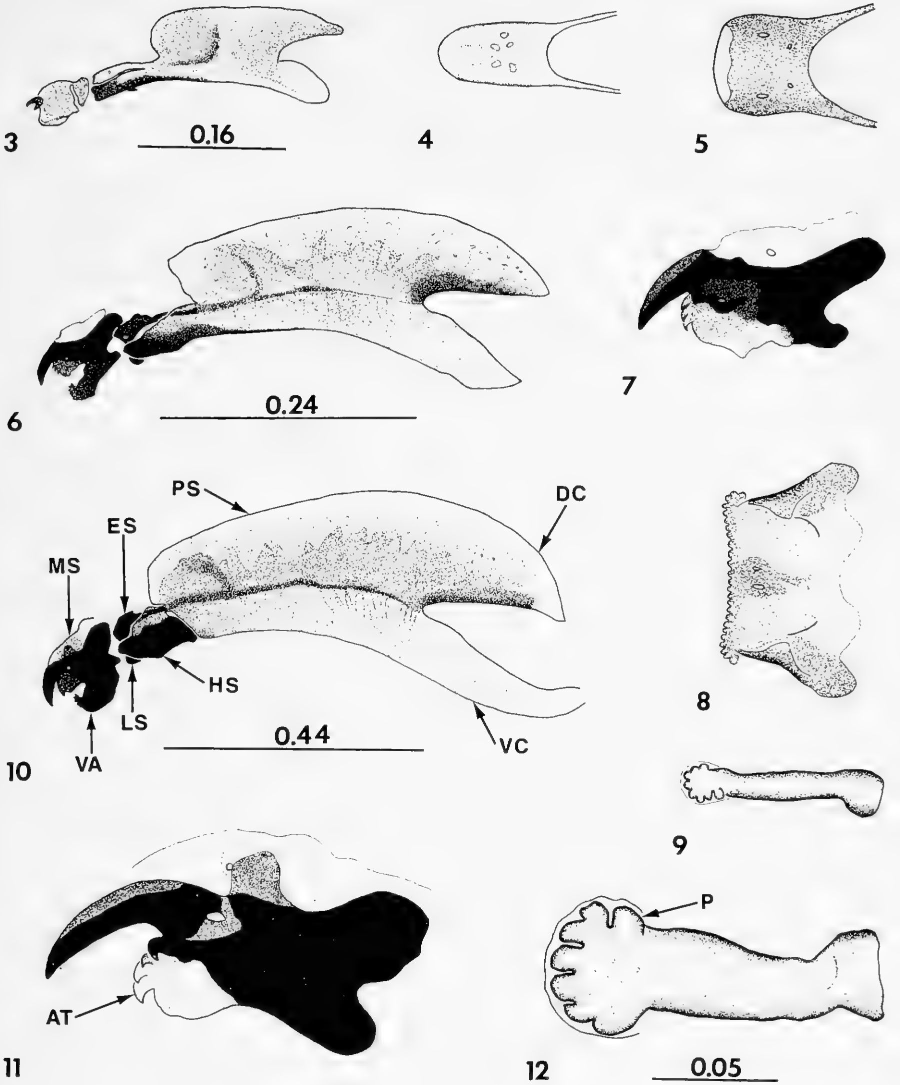
Puparia of the *Sepedon* Group have the posterior end curved dorsally so that the posterior spiracles with their hydrofuge float hairs project above the water surface. The anterior spiracles project only slightly from the anterolateral angle of the puparium. The body surface retains to some extent the color pattern of the mature larva, and it frequently has a distinctive texture, with lateral bumps and grooves.

Sepedonea isthmi (Steyskal)

Egg.—Length 1.28–1.38 mm; greatest width 0.30–0.36 mm. White. Elongate-ovoid. Dorsum with 2 prominent longitudinal ridges. Small dorsolateral ridge visible dorsally. Anterior and posterior poles with distinct punctures. Reticulations on chorion strongest between dorsal ridges, becoming faint laterally and ventrally. Based on 10 specimens.

First-instar larva (Figs. 3, 4).—Length 1.8–3.4 mm; greatest width 0.3–0.4 mm. White. Integument transparent, sparsely covered with spinules as compared to later larval instars. Cephalopharyngeal skeleton (Fig. 3) length 0.29–0.32 mm; mandibular sclerite composed of darkly pigmented, small, decurved portion anteriorly, a larger intermediate portion, and a darkly pigmented, triangular portion posteriorly, the latter connected to intermediate portion by a thin strap; ventral arch below intermediate portion; epistomal sclerite (Fig. 4) with 5 windows; hypostomal sclerite fused to pharyngeal sclerite, hypostomal plate with 4–6 windows; pharyngeal sclerite light brown, darker along pharyngeal indentation and at anterior ⅓ of sclerite; indentation index 30–37. Metapneustic. Segments 5–10 with inner and outer dorsal tubercles contiguous, hair covered. Segment 11 with number of hairs on dorsal tubercles greatly reduced. Spiracular plates light tan, with B-shaped spiracular openings. Anal proleg with short decurved spinules. Spiracular disc, except bare central area, with many long, fine hairs. Based on 25 specimens.

Second-instar larva (Figs. 5–9).—Length 3.8–4.5 mm; greatest width 0.6–0.8 mm. Light tan to brown. Integument translucent, densely covered with spinules. No middorsal stripe or dorsolateral V-shaped stripes. Cephalopharyngeal skeleton (Fig. 6) length 0.48–0.58 mm; mandibular sclerite (Fig. 7) 0.11–0.12 mm long, with 3–4 accessory teeth; ventral arch (Fig. 8) with 21–26 teeth anteriorly; epistomal sclerite (Fig. 5) with 4 windows; hypostomal sclerite fused to pharyngeal sclerite, hypostomal plate with 4 windows; pharyngeal sclerite without dorsal wing; indentation index 31–

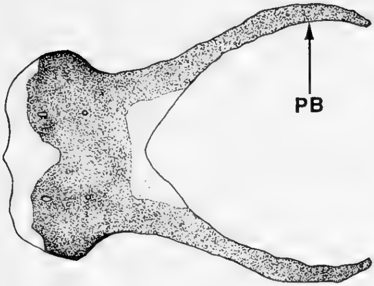


Figs. 3–12. Larval structures of *Sepedonea isthmi.* 3. First-instar larva, cephalopharyngeal skeleton; 4. Same, epistomal sclerite and parastomal bars; 5. Second-instar larva, epistomal sclerite and parastomal bars; 6. Same, cephalopharyngeal skeleton; 7. Same, mandibular sclerite; 8. Same, ventral arch; 9. Same, anterior spiracle; 10. Third-instar larva, cephalopharyngeal skeleton; 11. Same, mandibular sclerite; 12. Same, anterior spiracle. The scale for figures 4, 5, 7–9, 11, and 12 is below figure 12. (AT = accessory tooth, DC = dorsal cornu, ES = epistomal sclerite, HS = hypostomal sclerite, LS = ligulate sclerite, MS = mandibular sclerite, P = papilla, PS = pharyngeal sclerite, VA = ventral arch, VC = ventral cornu).

35. Anterior spiracles (Fig. 9) light tan, with long tubular basal part; rounded distal part with 8 marginal papillae. Segments 1–10 as in third-instar larva. Segment 11 with inner and outer dorsal tubercles greatly reduced; dorsolateral tubercle absent. Anal proleg without hooks. Based on 7 specimens.

Third-instar larva (Figs. 10–16).—Length 5.3–10.8 mm; greatest width 0.9–1.8 mm. Light tan to dark brown; integument subopaque. Light to dark middorsal stripe on segments 3–11; dorsolateral V-shaped stripes also present. Cephalopharyngeal skeleton (Fig. 10) length 0.79–0.88 mm. Indentation index 36–38. Paired mandibular sclerites (Fig. 11) connected dorsally; mouthhook darkly pigmented, strongly decurved; basal part with 2 windows. Ventral arch (Fig. 16) below and either joined to or articulating with basal part of mandibular sclerite; anterior margin with 22–26 short, blunt teeth; 2 longitudinal slits anteromesially, circular to transverse slits posterolaterally; pigmented part of arch with posteromedian indentation. Epistomal sclerite (Fig. 13) with 4 windows, anterior margin hyaline, remainder mostly darkly pigmented. Parastomal bars fused to paired pharyngeal sclerites and continuing to pharyngeal indentation as salient dark lines. Hypostomal sclerite (Fig. 15) darkly pigmented except for dorsal wing and hypostomal plate, the latter between anterior rami of the sclerite and with 4 windows; connected to pharyngeal sclerite by thin strap. Ligulate sclerite darkly pigmented. Pharyngeal sclerites with medium pigmentation, except for hyaline area at posterior tip of ventral cornu, lightly pigmented to hyaline area along dorsal surface, and hyaline strip along ventral midline.

Segment 1 longitudinally bilobed anteriorly, each lobe bearing sensory papilla; postoral spine band posteroventrally and partially extending up sides of segment. Segment 2 with ring of 8 setae around anterior end; bearing anterior spiracles posterolaterally. Anterior spiracles (Fig. 12) light tan, with tubular basal part; rounded distal part bearing 7–8 marginal papillae. Segments 3 and 4 with 1 dorsal and 1 lateral seta, and 3 setae on small ventral tubercle. Segments 5–10 with small, rounded inner dorsal tubercle covered with many long, fine hairs, usually 1 longer and heavier than others; a wide, hair-covered outer dorsal tubercle; a small, rounded dorsolateral tubercle with approximately 4 short hairs; a group of 3 lateral tubercles, including upper and lower lateral tubercles, each with 1 long seta, the former also with a group of about 4 shorter hairs, and a middle lateral tubercle, smaller and slightly anterior to the others and with group of about 4 short hairs; a ventral tubercle group consisting of a conspicuous middle row of 4 tubercles, each with tuft of about 4 short hairs, an anterior row of 2 widely separated tubercles, each with tuft of about 4 hairs, and a posterior row apparently devoid of distinct tubercles and appearing as creeping welt. Segment 11 with inner and outer dorsal tubercles reduced, the latter with only 2 long



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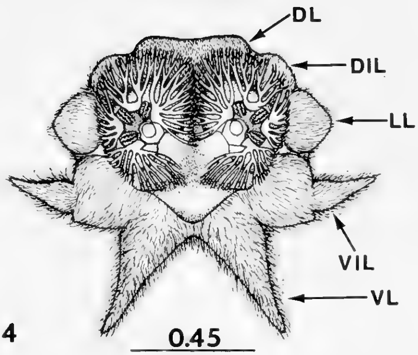

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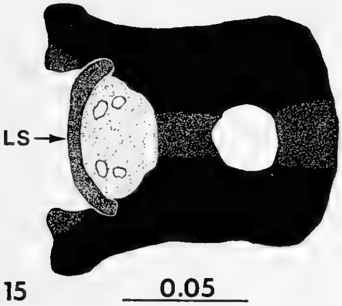

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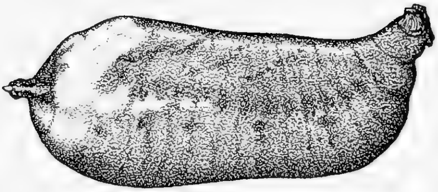

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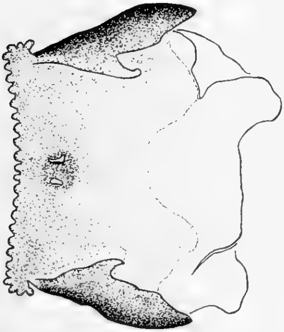

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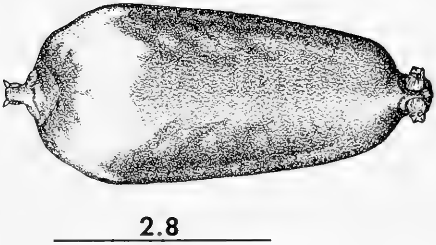

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Figs. 13–18. Larval structures and puparium of *Sepedonea isthmi.* 13. Third-instar larva, epistomal sclerite and parastomal bars; 14. Same, posterior spiracular disc; 15. Same, ligulate sclerite and venter of hypostomal sclerite; 16. Same, ventral arch; 17. Puparium, lateral view; 18. Same, dorsal view. The scale for figures 13, 15, and 16 is below figure 15. (DL = dorsal lobe, DlL = dorsolateral lobe, LL = lateral lobe, PB = parastomal bar, VL = ventral lobe, VlL = ventrolateral lobe.)

hairs; dorsolateral tubercle reduced (may be absent); lateral and ventral tubercle groups as in segment 5–10, except the posterior row of ventral tubercle group reduced or absent.

Segment 12 with small lateral tubercle above base of hookless anal proleg; perianal pad bordering anal proleg posteriorly. Posterior spiracular disc (Fig. 14) with conspicuous ventral and ventrolateral lobes, the former long and tapered, the latter, 2-segmented, with basal segment truncate and apical segment digitiform; dorsal, dorsolateral, and lateral lobes smaller, rounded, and inconspicuous; lobes covered with many fine hairs; central area of disc base bare. Paired spiracular plates at apices of sclerotized, basally scalloped, stigmatic tubes; each plate with 3 diverging, elongate-oval spiracular slits, a stigmatic scar, and 4 branching interspiracular float hairs. Based on 5 specimens.

Puparium (Figs. 17, 18).—Length 5.3–6.0 mm; greatest width 1.9–2.3 mm. Yellow to dark brown. Translucent to opaque. Barrel-shaped with anterior end narrow, tapered; posterior end sharply upturned. Cephalopharyngeal skeleton as in third-instar larva. Yellowish anterior spiracles protruding from anterolateral corners of dorsal cephalic caps. Most of dorsum of segments 5 and 6 yellow. Dorsum with 3–4 brown, V-shaped stripes extending to middle tubercle groups. Yellow lateral line extending from segment 5, where it is infuscated with brown to posterior end of puparium, below junction of segments 11 and 12. Area below lateral line largely brown with ventral tubercles yellow. Posterior spiracular disc with lobes shrunken; float hairs inconspicuous; stigmatic tubes yellow. Anal plate invaginated; anal proleg inconspicuous. Dorsal and dorsolateral tubercles reduced, hair patches closely appressed to the surface. Based on 4 specimens.

Acknowledgments

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Institute, Ottawa, Canada, for making specimens of S. *isthmi* available to us, and C. O. Berg and J. Abercrombie, Environmental Technology Division, Chemical Systems Laboratory, U.S. Army Armament Research and Development Command, Aberdeen Proving Ground, Maryland, for reviewing the manuscript.

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(LK) Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. Educ. Admin., USDA, Beltsville, Maryland 20705; and (KV) Department of Entomology, Cornell University, Ithaca, New York 14853.

Present address.—(KV) Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania 17120.

Footnote

[1] This species is considered as a possible synonym of *Galba viridis* (Quay and Giaimard) by B. Hubendick, 1951, Recent Lymnaeidae, Kungl. Svensk. Vittenskapakad, Fjärdel 1, Bd. 3, no. 1, pp. 1–223, 5 pls.

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NOTES ON THE BIOLOGY OF *DIGLYPHUS INTERMEDIUS* (HYMENOPTERA: EULOPHIDAE), A PARASITE OF THE ALFALFA BLOTCH LEAFMINER, *AGROMYZA FRONTELLA* (DIPTERA: AGROMYZIDAE)

R. M. Hendrickson, Jr. and S. E. Barth

Abstract.—Diglyphus intermedius (Girault) is the most common parasite of the alfalfa blotch leafminer, *Agromyza frontella* (Rondani), on alfalfa in Delaware, southcentral Pennsylvania, and southern New Jersey. It is a larval ectoparasite of leafminer larvae and is usually solitary; however, occasionally 2–5 parasites develop on a single host. It paralyzed and killed all three larval instars of its host agromyzids without ovipositing though it usually oviposited and developed on 3rd-instar larvae. The parasite has three instars as measured by changes in mandible length. At a constant 25.5°C, it developed from egg to adult in 11 days, lived 3–4 weeks as an adult and had an average fecundity of 40 offspring per female.

The alfalfa blotch leafminer (ABL), *Agromyza frontella* (Rondani), an introduced pest of European origin, was first observed in the USA in Hampshire County, Massachusetts, in 1968 (Miller and Jensen, 1970). It is usually a subeconomic pest on alfalfa throughout the northeastern USA and adjoining Canadian provinces, but occasionally it has become a serious pest (100–200 adults collected/sweep (Kim, 1975)). We report here notes on the biology of the most important of the native parasites of ABL, *Diglyphus intermedius* (Girault).

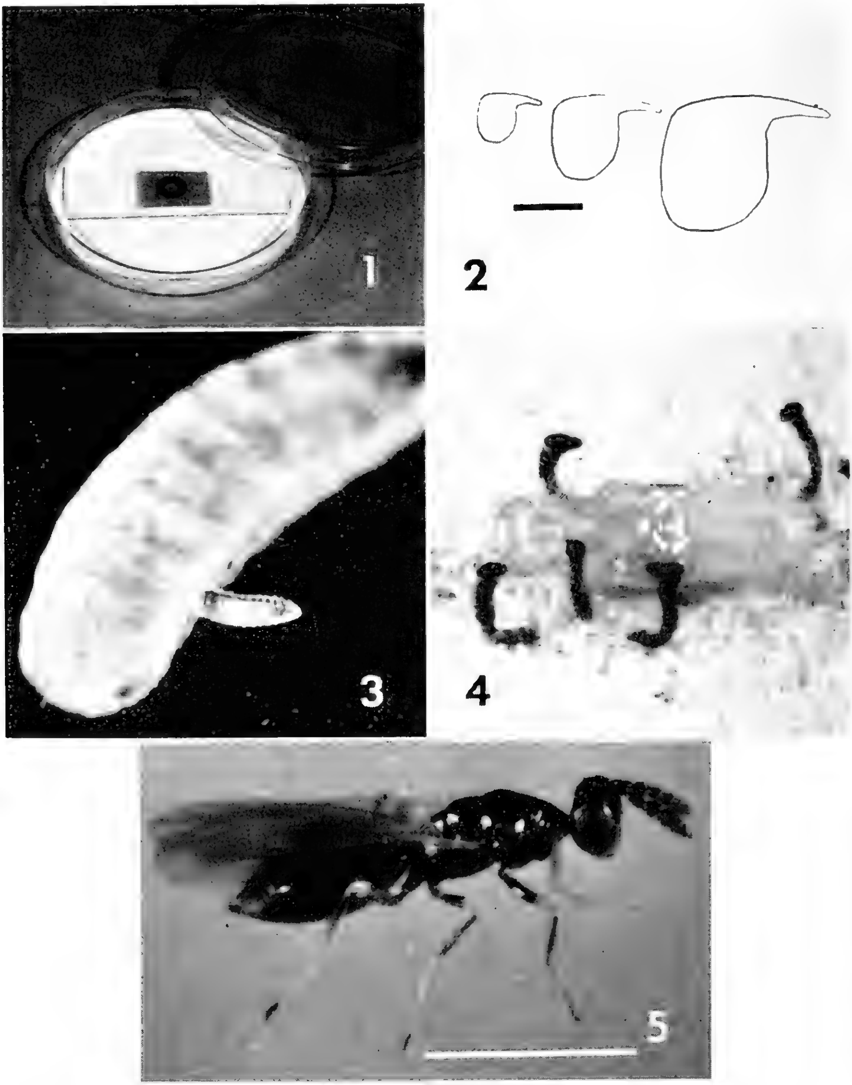
Diglyphus intermedius is a Nearctic species that has been reported to parasitize *Liriomyza subpusilla* Frost in California and *Phytomyza atricornis* Meigen in Rhode Island (Peck, 1963); *Liriomyza sativae* Blanchard (= *Liriomyza prosperpusilla* Frost) in Florida and Illinois (Burks, 1967); *Phytomyza chrysanthemi* Kowarz in Rhode Island (Peck, 1951); and *Liriomyza brassicae* (Riley) in California (Spencer, 1973). We have collected it from *Liriomyza trifoliearum* Spencer on alfalfa throughout the northeastern USA.

Laboratory Studies

All the life history studies of *Diglyphus intermedius* in the laboratory were conducted on a native agromyzid, *Liriomyza trifoliearum* Spencer, obtained from field-collected alfalfa and maintained in a laboratory colony on "Bountiful" bush snap bean, *Phaseolus vulgaris* L., and "Thaxter" lima bean, *Phaseolus limensis* Macf., in caged plants at 25.5 ± 1.1°C and 60 ± 5% RH with a photoperiod of 16L:8D. Observations on larval development were made by constructing artificial mines because *Diglyphus intermedius* develops entirely within the host's mine, and development there is obscured by the leaf tissue. The mine consisted of a microscope slide on which we placed a small square of blotter paper. A circle of construction paper with a hole in it, similar in size and shape to the gummed reinforcements used for notebook paper, was laid on the blotter paper. In the central hole was placed a parasitized leafminer larva that had been dissected from the leaf mine. A coverslip was placed on top of the larva to prevent any mobile parasite larva from leaving the artificial mine. The entire slide was placed in a closed petri dish that had moistened plaster of Paris (Fig. 1) or sand on the bottom to maintain a high RH. The slide was removed from the petri dish for observation by microscope. Since the majority of parasites handled in this way survived from egg to adult, the technique could be applied to the study of other larval ectoparasites of leafminers.

The number of instars was determined by exposing 3rd-instar hosts to adult parasite adults for 15 h. When the parasites were removed at 0800 h, that hour was counted as the beginning of the first day of maturation of the parasite though, in some cases, as much as 15 h had elapsed. Then at 0800 h on succeeding days, parasite larvae were removed and mounted on slides in Hoyer's medium. The instar was determined by measuring the length of the mandibles from the tip of the "tooth" to the posterior margin of the dorsal process (the greatest distance across the mandible). The length of a single mandible averaged 10 μ ($n = 12$, range = 6–13 μ) for the 1st instar, 17 μ ($n = 7$, range = 15–19 μ) for the 2nd instar, and 27 μ ($n = 11$, range = 23–30 μ) for the 3rd instar (Fig. 2). These observations were corroborated by measuring the mandibles of larvae in eggs shortly before eclosion, and those in cast skins. Therefore, we concluded that the parasite had three larval instars. A 1st-instar parasite larva feeding on a *Liriomyza trifoliearum* larva is shown in Fig. 3.

From the observations of the larval parasites in artificial mines, it was found that at 25.5°C development from egg to adult required 11 days: 1 day for the egg stage, 4 for the larval stage and 6 for the pupal stage. The egg hatched within 24 h after it was laid, and if it was not already attached to the host, the young parasite larva sought out the host and began feeding immediately. The 1st instar lasted about 24 h, the 2nd less than 24 h and the 3rd about 2½ days. On the 3rd day, the larva changed from light yellow to a lime-bluish green and soon constructed 6–8 meconial pillars that extended from the upper to the lower surface of the mine. Since these pillars are usually arranged in pairs on each side of the pupa (Fig. 4), they apparently protect the pupa from being crushed if the leaf dries out and also prevent the pupa from rolling about inside the mine. When the parasite transformed to the adult stage (Fig. 5) in the host's mine, it chewed an oval hole in the upper epidermis of the leaf and left the mine.



Figs. 1–5. 1. Artificial mine. Parasite and host are inside black paper ring with coverslip placed on top. Plaster of Paris in petri dish was moistened to maintain high humidity; 2. Mandibles of 1st-, 2nd-, and 3rd (final)-instar *Diglyphus intermedius* larvae. Bar is 10 μ; 3. First-instar *D. intermedius* larva feeding on 3rd-instar *Liriomyza trifoliearum* host. Bar is 0.1 mm; 4. Meconial pillars around *Diglyphus intermedius* pupa. Tops of pillars are attached to underside of coverslip; 5. Adult female *D. intermedius.* Bar is 1 mm.

Repeated attempts to observe mating in cages of various sizes, with and without hosts, were unsuccessful. Mating was infrequently observed in maintenance culture cages containing thousands of parasites.

Oviposition of *Diglyphus intermedius* was studied by confining parasite adults in a petri dish with a bean leaf mined by 3rd (final)-instar hosts. The activity could then be observed through a microscope. The searching behavior of the female parasite consisted of palpating the leaf until a mine was located. Then she followed the mine by swaying back and forth, almost in a rhythmic motion, while she palpated the mine alternately with each antenna. Once she discovered a host, she immediately circled above it and palpated the leaf epidermis with her antennae. The host larva apparently sensed the presence of the parasite above the mine and often began to thrash around within the confines of the mine, even before the parasite penetrated the mine with the ovipositor. Within seconds after locating a host, the parasite attempted to sting it and the host responded to each attempted sting by making a rapid twisting motion in an apparent attempt to avoid the ovipositor. The parasite was observed to sting and kill each of the three host instars, but oviposition was never observed on 1st-instar larvae. Stinging without oviposition lasted from 2–14 s. After several stings, the host ceased movement, but the hindgut was observed to continue to function until waste matter was expelled; then the larva became completely immobile. More prolonged stings, average 39 s ($n = 6$, range = 25–53 s), were assumed to be oviposition attempts. The parasite commonly oviposited 1–2 eggs/host, but on one occasion three eggs were laid. Eggs were ordinarily placed on the host larva, but occasionally some were placed 1–2 mm from the host but within the mine. Oviposition usually occurred on 3rd-instar hosts, but in one case, a female was observed to sting a 2nd-instar larva nine times and to lay one egg on the host. Since attempts to rear the parasite on 2nd-instar host larvae were unsuccessful, we suspect that such *Liriomyza trifoliearum* larvae do not usually provide sufficient food to allow complete development of the parasite.

Fecundity of the parasite was determined by confining a single female, less than 24 h old, with two males on "Bountiful" bush snap beans heavily infested with 3rd-instar *L. trifoliearum*. The parasites were supplied with honey as food, and fresh host material was placed in the cage weekly until the female died. The plant material was removed and held for parasite emergence. The average fecundity was found to be 40.2 progeny per female ($n = 6$). Females in the test lived 3–4 weeks.

Parasites reared on "Bountiful" bush snap bean had a sex ratio of 1♀:2.2♂ ($n = 204$). However, the ratio on "Thaxter" lima bean was 1♀:1♂ ($n = 117$). A similar disparity was noted when we reared the European parasite *Diglyphus isaea* (Walker) on these two bean species.

Field Observations

Samples of 50 alfalfa leaflets mined by either ABL or *Liriomyza* spp. were collected weekly from early May through November 1975, from each of seven fields (one at Newark, Delaware; three near Oxford, Pennsylvania; and three near Rancocas, New Jersey) unless the alfalfa was cut or bad weather prevented fieldwork. If populations of agromyzid larvae were low, a sample consisted of as many mined alfalfa leaflets as could be collected in each field in 20 min. In the laboratory, the mined leaflets were placed in petri dishes (50 mm diam with tight-fitting lids) on slightly moistened filter paper, which retained moisture for 3–4 weeks, long enough for the parasites to develop and emerge at 22.2 ± 1.1°C. The host larvae were separated by mine character. ABL, in the 1st and early 2nd instar, formed a fairly straight linear mine; in late 2nd and throughout the 3rd instar it produced a large blotch mine. *Liriomyza* spp. formed a serpentine, linear mine in all three instars. The instar of the host was determined by measuring the length of the cephalopharyngeal skeleton by transmitted light under the microscope and comparing it to predetermined length ranges for each instar for each species.

Diglyphus intermedius parasitized a total of 9.2% of the ABL larvae collected from the field ($n = 4{,}748$), but actual field mortality due to the parasite was probably higher than that. We did not include larvae killed by parasite stinging without oviposition because they could not be easily separated from those killed by predators, diseases, overcrowding in the leaflet, or environmental factors. Total parasitism of ABL by all parasitic species was 18.8% and *D. intermedius* accounted for almost 50% of this amount. *Diglyphus intermedius* preferred 3rd (final)-instar larvae, although 23.7% of the hosts were 2nd-instar larvae. Thus our inability to rear the parasite on 2nd-instar *Liriomyza trifoliearum* larvae in the laboratory was probably caused by the smaller size of the host.

The parasite was usually solitary but was gregarious on 13.3% of the larvae (2–5 adults from a single host).

Acknowledgments

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TERMINALIA OF SOME NORTH AMERICAN SPECIES OF *MEGASELIA* (*APHIOCHAETA*) AND DESCRIPTIONS OF TWO NEW SPECIES (DIPTERA: PHORIDAE)

William H Robinson

Abstract.—Borgmeier's (1964, 1966) revision of North American *Megaselia* lacked detailed figures of the adult terminalia. In this large genus the male epandrium and hypandrium and the female tergum and sternum 6 provide excellent distinguishing characters. This work presents a brief diagnosis and figures of the male and female terminalia of the following species of the subgenus *Aphiochaeta*: *Megaselia californiensis* (Malloch), *M. capta* (Borgmeier), *M. georgiae* Borgmeier, *M. decora* new species, *M. gravis* Borgmeier, *M. laffooni* new species, *M. marginalis* (Malloch), *M. melanderi* Borgmeier, *M. nigriceps* (Loew), *M. plebia* (Malloch), *M. proclinata* Borgmeier, *M. relicta* Borgmeier, *M. robusta* Schmitz. Two species of this group, *M. decora* and *M. laffooni*, are described as new.

Borgmeier's (1964, 1966) revision of the North American *Megaselia* placed the taxonomy of this genus on a firm foundation. He studied material in several U.S. collections and was able to examine nearly all the types of North American *Megaselia*. In this work Borgmeier provided descriptions and keys for about 260 *Megaselia* species. However, Borgmeier's revision lacks detailed figures of the adult terminalia. The external terminalia of the male (epandrium and hypandrium) and of the female (tergum 6) provide excellent characters for distinguishing species. The proper use of these characters along with other structural features in species descriptions could help remove some of the difficulties in accurately determining species of this genus.

The purpose of this work is to provide a brief diagnosis and the first detailed figures of the male and female terminalia of the *Megaselia* species in Borgmeier's (1964) Group I. Two new species, *Megaselia* (*Aphiochaeta*) *decora*, and *M.* (*A.*) *laffooni* are described.

Materials and Methods

This work is based on the study of 470 Nearctic specimens of the *Megaselia* species of Borgmeier's Group I. Specimens were seen from most states and provinces of U.S. and Canada, but not from Greenland and Mexico.

I have examined, or received information on, the holotypes of all the Nearctic species of Group I. Specimens of the type-series of Holarctic species were not available for examination at this time. Information on original descriptions and synonymies can be found in Borgmeier (1964).

The methods used for removing and preparing terminalia for study were similar to those used by other workers. Terminalia were permanently stored in 4 × 11 mm plastic vials, partially filled with glycerine and capped with rubber stoppers, and placed on the same pin as the insect.

External Terminalia of *Megaselia*

The external male terminalia of *Megaselia* species are platyperzid-like in appearance. A brief explanation will help to understand the simple structure of the preabdomen and postabdomen.

The preabdomen (segments 1–6) is moderately elongate and more or less cylindrical. The terga are generally unequal in size, and the sterna are absent.

The postabdomen of the male (Fig. 1) lies in a straight, longitudinal relationship with the preabdomen. Terga and sterna 7 and 8 are absent. The epandrium (EP, Fig. 1) is generally symmetrical and often has scattered setae laterally. The hypandrium (Fig. 2) is generally asymmetrical; the right side, and occasionally the left side, bears a setulose lobe that extends posteriorly. The proctiger (PR, Fig. 1) is well developed; the cerci are distinct (Fig. 1) and fused along the mid-line.

The postabdomen of the female consists of an elongate ovipositor that telescopes within segment 6. The ovipositor is entirely membranous—never forming a horny, nonretractile stylet. Terga and sterna 7 and 8 are reduced and are sometimes absent. The cerci are distinct and bear numerous setae.

Group I *Megaselia* (*Aphiochaeta*)

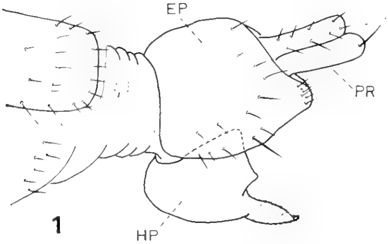
The practice of partitioning the hundreds of *Megaselia* species into eight "artificial" groups as frequently done by other authors (Lundbeck, 1922; Schmitz, 1956; Borgmeier, 1964) has been followed here. These groups provide an excellent, albeit abitrary, means of reducing the large numbers of species into small, workable taxonomic groups. The structural characters upon which these groups are based (see Borgmeier, 1964) are relatively constant and discernible on all but the poorest specimens.

Species of Group I can be distinguished by the setose mesanepisternum and the 4–6 scutellar bristles. This group is known from males of 13 Nearctic species, including the two new species described below; females are known for only 4 species of the Group.

Megaselia (*A.*) *nigriceps* (Loew) and *M.* (*A.*) *robusta* Schmitz are the only known Holarctic species of this group.

Megaselia (*Aphiochaeta*) *californiensis* (Malloch)
Figs. 11, 20

Diagnosis.—This species can be distinguished from other Nearctic *Aphiochaeta* species with 4–6 scutellars by the following combination of characters: Mesanepisternum without bristles; halter brown; fore basitarsus



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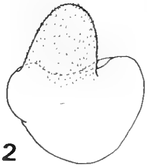

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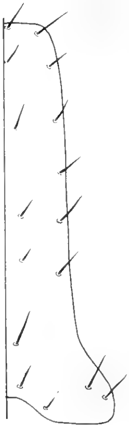

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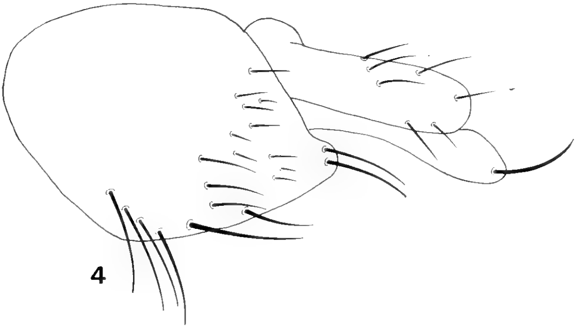

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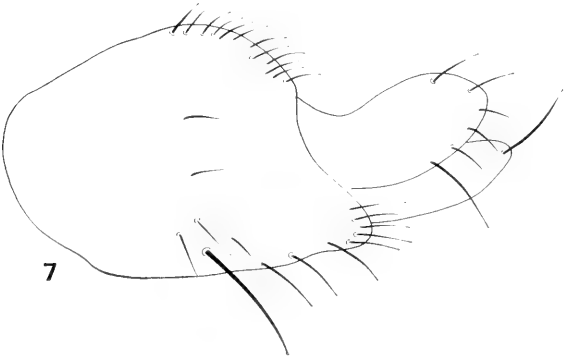

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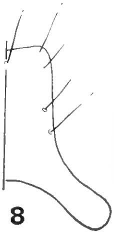

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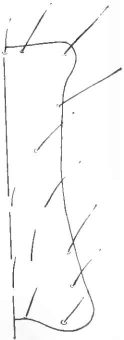

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enlarged apically; costa 48–52% of wing length. Terminalia: Epandrium (Fig. 11) short, with numerous bristles ventro- and posterolaterally; hypandrium (Fig. 20) bare, except for setulae on lobe. Female unknown.

Known distribution.—California, Washington.

Material examined.—Two ♂, 1♀.

Megaselia (*Aphiochaeta*) *capta* Borgmeier
Figs. 18, 19

Diagnosis.—The male differs from other Nearctic *Aphiochaeta* species with 4–6 scutellars by the character combination: Mesanepisternum with bristles; costa 41% of wing length. Terminalia: Epandrium (Fig. 18) curved under proctiger, with 1 strong bristle posterolaterally; hypandrium (Fig. 19) setulose laterally, setulae longer on lobe. Female unknown.

Known distribution.—Virginia.

Material examined.—Holotype.

Megaselia (*Aphiochaeta*) *georgiae* Borgmeier
Figs. 14, 21

Diagnosis.—The male differs from other Nearctic *Aphiochaeta* species with 4–6 scutellars by the character combination: Scutellum with 6 bristles; mesanepisternal bristle absent. Terminalia: Epandrium (Fig. 14) higher than wide, with numerous bristles, left side with long, unarticulated process directed posteroventrally; hypandrium (Fig. 21) setulose, with 1 long, slender, setulose lobe. Female unknown.

Known distribution.—Georgia.

Material examined.—Holotype.

Megaselia (*Aphiochaeta*) *decora* Robinson, new species
Figs. 5, 22

Diagnosis.—The male differs from other Nearctic *Aphiochaeta* species with 4–6 scutellars by the character combination: Mesanepisternum without bristles; propleuron with numerous scattered fine setae and bristles, and the presence of 2 supra-antennal bristles. Female unknown.

Description of male.—Body yellowish brown. Frons brown, dull, as wide as high; 1 pair of supra-antennals, more approximate than preocellars; inner frontal bristle midway between supra-antennal and outer frontal bristle;

←

Figs. 1–9. *Megaselia* spp. terminalia. 1. *M. nigriceps*, male terminalia; 2. *M. nigriceps*, male hypandrium; 3. *M. nigriceps*, female tergum 7; 4. *M. marginalis*, male epandrium; 5. *M. decora*, male epandrium; 6. *M. marginalis*, female tergum 7; 7. *M. gravis*, male epandrium; 8. *M. relicta*, female tergum 7; 9. *M. robusta*, female tergum 7.

posterior frontal bristle on slightly higher level than preocellar bristle. Parafacia with 3 bristles. Third antennal segment brown. Palpus brown.

Thorax brown; propleuron with numerous scattered setae, 1 strong ventral and 3 dorsal propleural bristles; mesanepisternum with about 22 fine setae, bristles absent. Scutellum with 4 bristles.

Abdominal terga brown; sterna yellowish brown. Terminalia long, brown; proctiger yellow; epandrium (Fig. 5) slightly longer than tergum 6, with scattered setae; hypandrium (Fig. 22) bilobed, lobes unequal, with setae.

Legs brownish yellow; fore tibia with small anterodorsal bristles, and 18 short, weak posterodorsal bristles; hair-seam extending 0.8 length of tibia; middle basitarsus with 2 weak bristles on basal ½. Hind femur with 9 decumbent bristles on basal ½; hind tibia with indistinct anterodorsals, 5 strong, widely spaced posterodorsals on apical ½, and 3–4 short posterodorsals on apical ½; hind basitarsus with 2 bristles near distal ½.

Wing 2.54 mm long; membrane hyaline, veins pale brown; costa 47% of wing length, ratio of first 2 costal divisions 2:3; costal bristles long; 6 axillary bristles. Halter entirely brownish yellow.

Material examined.—Holotype.

Holotype.—Male, Cowichan Lake, British Columbia, II-20-1964, J. A. Chapman. Type No. 15131, in the Canadian National Collection.

Remarks.—The type-specimen was apparently mounted from alcohol.

Megaselia (*Aphiochaeta*) *laffooni* Robinson, new species

Figs. 17, 23

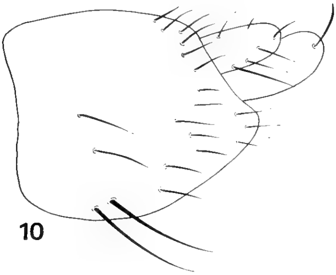
Diagnosis.—The male differs from other Nearctic *Aphiochaeta* species with 4 scutellars by the character combination: Mesanepisternum without bristles; costa 47% of wing length; knob of halter and palpus blackish brown. Female unknown.

Description of male.—Body blackish brown. Frons blackish brown, dull, as wide as high; supra-antennals subequal, lower pair closer than upper pair to median furrow, upper pair about as far as preocellar from median furrow; inner frontal bristle close to outer frontal bristle; posterior frontal bristle higher than preocellar. Parafacia with 5 bristles. Third antennal segment dark brown. Palpus blackish brown, narrow and pointed apically.

Thorax blackish brown; propleuron without scattered hairs, 3 ventral and 3 dorsal propleural bristles in a row adjacent to anterior spiracle; mesanepisternum with 8–10 fine setae, bristles absent. Scutellum with 4 bristles.

→

Figs. 10–18. *Megaselia* spp. male epandria. 10. *M. plebeia*; 11. *M. californiensis*; 12. *M. proclinata*; 13. *M. relicta*; 14. *M. georgiae*; 15. *M. melanderi*; 16. *M. robusta*; 17. *M. laffooni*; 18. *M. capta*.



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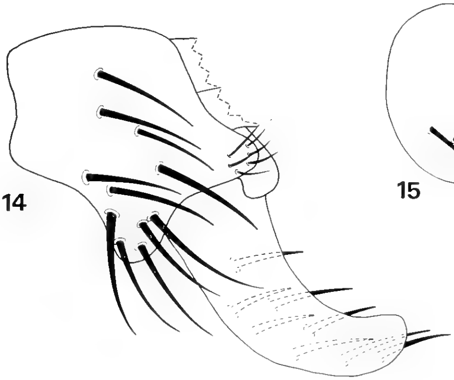

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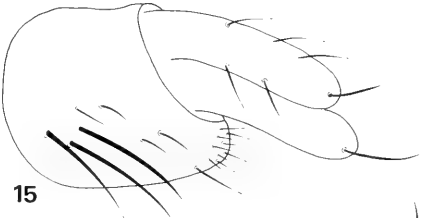

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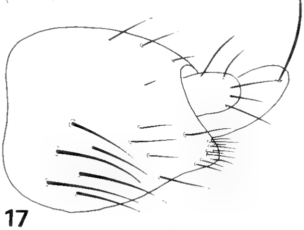

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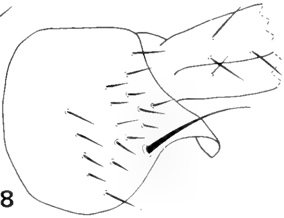

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Abdominal terga blackish brown; sterna brown. Terminalia small, blackish brown; proctiger small, pale brown; epandrium (Fig. 17) with strong bristles ventrally near base, and weak bristles posterolaterally; hypandrium (Fig. 23) with 1 lobe bearing fine setae.

Legs dark brown; fore tibia with indistinct antero- and posterodorsal bristles; fore basitarsus enlarged, broader than apex of fore tibia. Middle tibia with 8 anterodorsals and 4 weak, decumbent posterodorsal bristles; hairseam extending ½ length of tibia; middle basitarsus with 2 weak bristles on basal ⅓. Hind femur with 7 short, widely spaced fine setae on slightly more than ½; basal hind tibia with indistinct anterodorsal bristles, 14 posterodorsal bristles that are weak on basal ½ of row; hair seam; strongly arched. Hind basitarsus with 1 bristle on basal ⅓.

Wing 1.62 mm long; membrane pale brown, veins dark brown; costa 47% of wing length, ratio of first 2 costal divisions 2:0; costal bristles long; 4 axillary bristles. Halter entirely blackish brown.

Material examined.—Holotype.

Holotype.—Male, Isabel Pass, 2,900′, mile 206, Richardson Highway, III-13-1962, P. J. Skitsko. Type No. 15132, in the Canadian National Collection.

Remarks.—I take pleasure in naming this phorid for the late Dr. Jean L. Laffoon of Iowa State University. As a scholar, teacher, dipterist and friend he was as unique as this species.

Megaselia (*Aphiochaeta*) *gravis* Borgmeier

Figs. 7, 24

Diagnosis.—The male differs from other Nearctic *Aphiochaeta* species with 4–6 scutellars by the following combination of characters: Mesanepisternum without bristles; costa 55% of wing length; and hind femur with 8 long bristles on basal ½. Terminalia: Epandrium (Fig. 7) setulose dorsally; hypandrium (Fig. 24) setulose laterally, lobe setulose and with long, fine setae apically. Female unknown.

Known distribution.—Alaska.

Material examined.—Holotype.

Megaselia (*Aphiochaeta*) *marginalis* (Malloch)

Figs. 4, 6, 25

Diagnosis.—This species differs from other Nearctic *Aphiochaeta* species by the combination of 6 scutellar and 1 mesanepisternal bristle. Terminalia: Epandrium (Fig. 4) subshining dorsally, setose laterally, with 4–6 bristles ventrally near base; hypandrium (Fig. 25) symmetrical, bilobed. Oviscapt: Tergum 7 (Fig. 6) broad, with 4 fine apical setae; sternum 7 narrow, Y-shaped and with 2 apical setae on each fork of Y.

Known distribution.—Florida, Georgia, Iowa, Kansas, Maryland, Michigan, Missouri, New York, Tennessee, Virginia, Wisconsin.

Material examined.—Sixteen ♂, 7♀.

Remarks.—This species is structurally similar to *M. georgiae* (Nearctic), and *M. flavicoxa* (Palearctic).

Biology.—Two females were collected from the cell of the scarab beetle *Peltotrupes youngi* Howden, in Florida.

Megaselia (Aphiochaeta) melanderi Borgmeier
Figs. 15, 26

Diagnosis.—The male differs from other Nearctic *Aphiochaeta* species with 4 scutellars by the character combination: Costa 53% of wing length; costal bristles long; halter and palpus brown. Terminalia: Epandrium (Fig. 15) with scattered setulae and 6–8 bristles; hypandrium (Fig. 26) setulose, bilobed, right lobe longer than left. Female unknown.

Known distribution.—Florida (Royal Palm Park).

Material examined.—Holotype.

Remarks.—The type-locality for this species is about 35 miles southwest of Miami, Florida. This region might be considered transitional between the Nearctic and Neotropical regions.

Megaselia (Aphiochaeta) nigriceps (Loew)
Figs. 1, 2, 3

Diagnosis.—This species differs from other Nearctic *Aphiochaeta* species with 4 scutellars by the character combination: Mesanepisternum without bristles; scutellars long, subequal; costa 50–53% of wing length. Terminalia: Epandrium (Fig. 1) setulose posterolaterally and with 1–2 long bristles ventrally; hypandrium (Fig. 2) bare except for setulose lobe. Oviscapt: Tergum 7 (Fig. 3) long, arched basally.

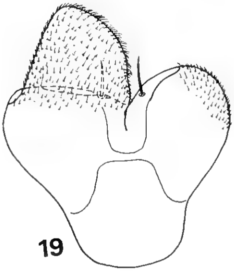
Known distribution.—Widespread in U.S. and western Canada.

Material examined.—Two hundred twelve ♂, 155 ♀.

Remarks.—The coloration of this species ranges from yellowish brown to blackish brown. The darker individuals seem to have a predominantly northern distribution and the paler individuals have a more southern distribution. The male palpus and fore basitarsus are generally large, but in some specimens they are slender. The record of this species feeding on garbage (Aldrich, 1897) was an error; Aldrich actually had specimens of *M. cavernicola* (Brues).

Megaselia (Aphiochaeta) plebia (Malloch)
Figs. 10, 27

Aphiochaeta pallidiventris Malloch, 1919:47. NEW SYNONYMY.
Megaselia (Aphiochaeta) wirthi Borgmeier, 1964:277. NEW SYNONYMY.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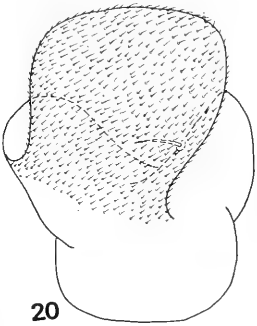
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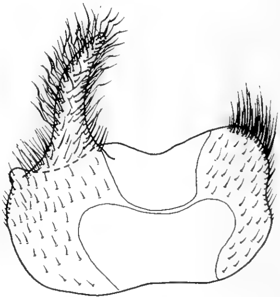
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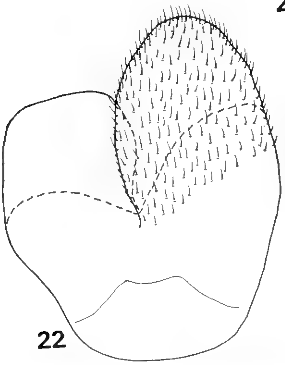
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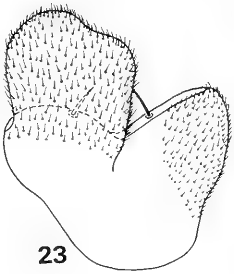
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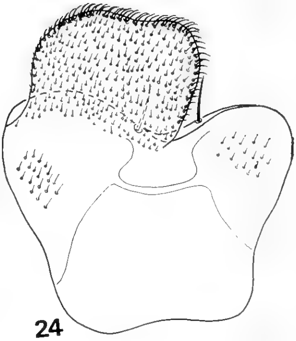
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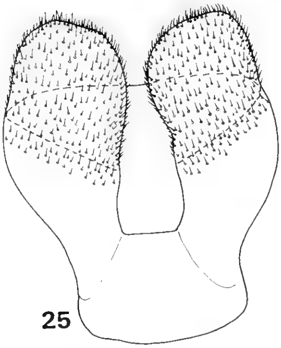
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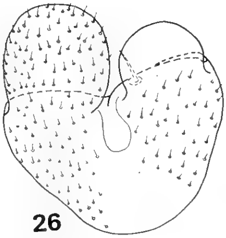
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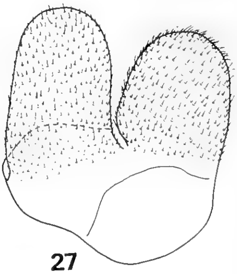
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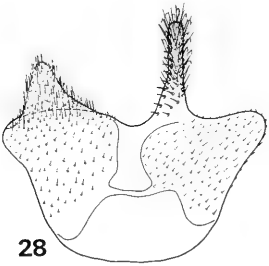
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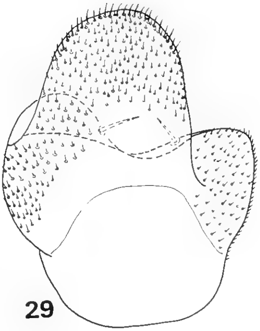
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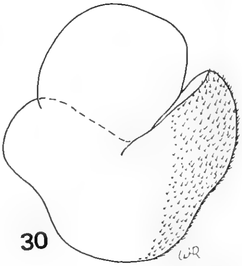
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Diagnosis.—This species differs from other Nearctic *Aphiochaeta* species by the character combination: Mesanepisternum with 1–2 bristles; fore tibia with 12–14 strong anterodorsal bristles; halter yellow; costa 45–50% of wing length. Terminalia: Epandrium (Fig. 10) with 2 strong bristles ventrally near base; hypandrium (Fig. 27) setulose. Oviscapt; Terga and sterna 6 and 7 absent.

Known distribution.—Arkansas, Kansas, South Carolina, Virginia.

Material examined.—Fifteen ♂, 12♀.

Remarks.—The female of this species is very striking in having tergum 1 dark brown, terga 2–3 entirely or in part pale brown to brownish orange, and terga 4–6 yellowish orange. *Megaselia plebeia* was apparently described from pharate adult males (not 1 male and 2 females as stated by Malloch, 1914). The female of this species *(M. pallidiventris)* may have been described as new because of the striking coloration of the abdomen and inadequate description of *M. plebeia*. Borgmeier (1964) described *M. wirthi* before seeing the types of *M. plebeia* and *M. pallidiventris*.

Megaselia (*Aphiochaeta*) *proclinata* Borgmeier
Figs. 12, 28

Diagnosis.—The male can be distinguished from other Nearctic *Aphiochaeta* species by the presence of 6 supra-antennal bristles. Terminalia: Epandrium (Fig. 12) small, higher than wide, with numerous bristles posterolaterally, left side with long, unarticulated process directed posteriorly; hypandrium (Fig. 28) setulose laterally, bilobed. Female unknown.

Known distribution.—Virginia.

Material examined.—Holotype.

Remarks.—The presence of 6 supra-antennal bristles is unique for this group of species. It is possible that one pair are supernumerary. However, the male of *M. proclinata* is easily recognized, also, by the unusual shape of the epandrium.

Megaselia (*Aphiochaeta*) *relicta* Borgmeier
Figs. 8, 13, 30

Diagnosis.—This species differs from other Nearctic *Aphiochaeta* species with 4 scutellars by the character combination: Mesanepisternum with 1 bristle; halter brown; costa 46–47% of wing length. Terminalia: Epandrium (Fig. 13) shining, right side with short, unarticulated process posterolat-

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Figs. 19–30. *Megaselia* spp. male hypandria. 19. *M. capta*; 20. *M. californiensis*; 21. *M. georgiae*; 22. *M. decora*; 23. *M. laffooni*; 24. *M. gravis*; 25. *M. marginalis*; 26. *M. melanderi*; 27. *M. plebia*; 28. *M. proclinata*; 29. *M. robusta*; 30. *M. relicta*.

erally; hypandrium (Fig. 30) setulose laterally on right side, lobe without setulae. Oviscapt: Tergum 7 (Fig. 8) short, an inverted-Y-shape.

Known distribution.—Illinois, Iowa, Kansas, Washington.

Material examined.—Two ♂, 3 ♀.

Megaselia (*Aphiochaeta*) *robusta* Schmitz
Figs. 9, 16, 29

Diagnosis.—The male differs from other Nearctic *Aphiochaeta* species with 4 scutellars by the presence of a row of 10–12 short ventral bristles on the basal ⅓ of the hind femur. Terminalia: Epandrium (Fig. 16) with 4–6 scattered bristles and 1 long bristle; hypandrium (Fig. 29) setulose laterally on right. The female differs by the character combination: Mesanepisternum without bristles; palpus narrow and with 1 row of ventral bristles; halter yellowish brown; costa 50–55% of wing length. Oviscapt: Tergum 7 (Fig. 9) broad, slightly arched basally.

Known distribution.—Alaska, western Canada, New Hampshire, northern Europe.

Material examined.—Nineteen ♂, 21♀.

Biology.—The holotype was reared from larvae in decaying vegetation.

Discussion

The Groups in the genus *Megaselia* are practical entities and are not necessarily monophyletic. A review of the figures presented in this paper indicates considerable variation in the male terminalia of Group I *Megaselia.* There are some species with primitive, platypezid-like terminalia, and some with more derived terminalia features.

The Group I *Megaselia* species (North America) with the most primitive terminalia features include *M. decora, M. marginalis, M. melanderi, M. plebeia, M. proclinata* and *M. relicta.* The male terminalia of these species is characterized by one or more unsegmented processes on the epandrium and/or a bilobed hypandrium.

There are two species in which these conditions can be seen best. In *M. proclinata* (Fig. 12) the epandrium has an elongate, unsegmented process similar to the surstyles of platypezids. The hypandrium of *M. marginalis* (Fig. 25) represents the most primitive, unspecialized condition. It is symmetrical and bilobed, and the lobes are of equal size.

The Group I *Megaselia* species with the most derived terminalia features include *M. californiensis, M. capta, M. georgiae, M. gravis, M. laffooni, M. nigriceps* and *M. robusta.* The terminalia of these species is characterized by a simple epandrium, without lateral processes (except in *M. georgiae*), and/or a single-lobed hypandrium.

As knowledge of the male and female terminalia of *Megaselia* increases, so will our ability to construct a phylogenetic classification of this genus.

Acknowledgments

I gratefully acknowledge the time and counsel contributed to this research by the late Dr. Jean L. Laffoon. Drs. B. V. Peterson, Biosystematics Research Institute, Agriculture Canada and W. W. Wirth and R. J. Gagné, Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA reviewed and improved the manuscript.

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Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

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TWO NEW SPECIES OF AMERICAN ARADIDAE (HEMIPTERA)

Nicholas A. Kormilev

Abstract.—The author proposes two new taxa, *Aradus oregonicus* new species and *A. usingeri* new species, both from Oregon and both belonging to the "Quilnus group." A new record and the description of a male is given for *Eunotoplocoris ruckesi* Kormilev (1957) from Peru.

By the kind offices of Dr. Harry Brailovsky, Instituto de Biologia UNAM, Mexico City, Mexico, and Prof. Dr. John D. Lattin, Oregon State University, Corvalis, Oregon, I have had an opportunity to study two lots of American Aradidae from collections under their care, for which I express my sincere gratitude.

Among other common species, two species of *Aradus* Fabricius, 1803, from Oregon, belonging to the "Quilnus group," were new and are described in this paper.

The genus *Eunotoplocoris* Kormilev (1957) was described based on a single female from Peru. Now I am able to give a description of a male of the same species, *Eunotoplocoris ruckesi* Kormilev, 1957.

All measurements in this paper were taken by micromillimeter eyepiece, 25 units = 1 mm. In ratios the first figure represents the length and the second the width of measured portion. The length of the abdomen in *Aradus* F., for convenience, was taken from the tip of the scutellum to the tip of the genital lobes.

Subfamily ARADINAE

Genus *Aradus* Fabricius, 1803

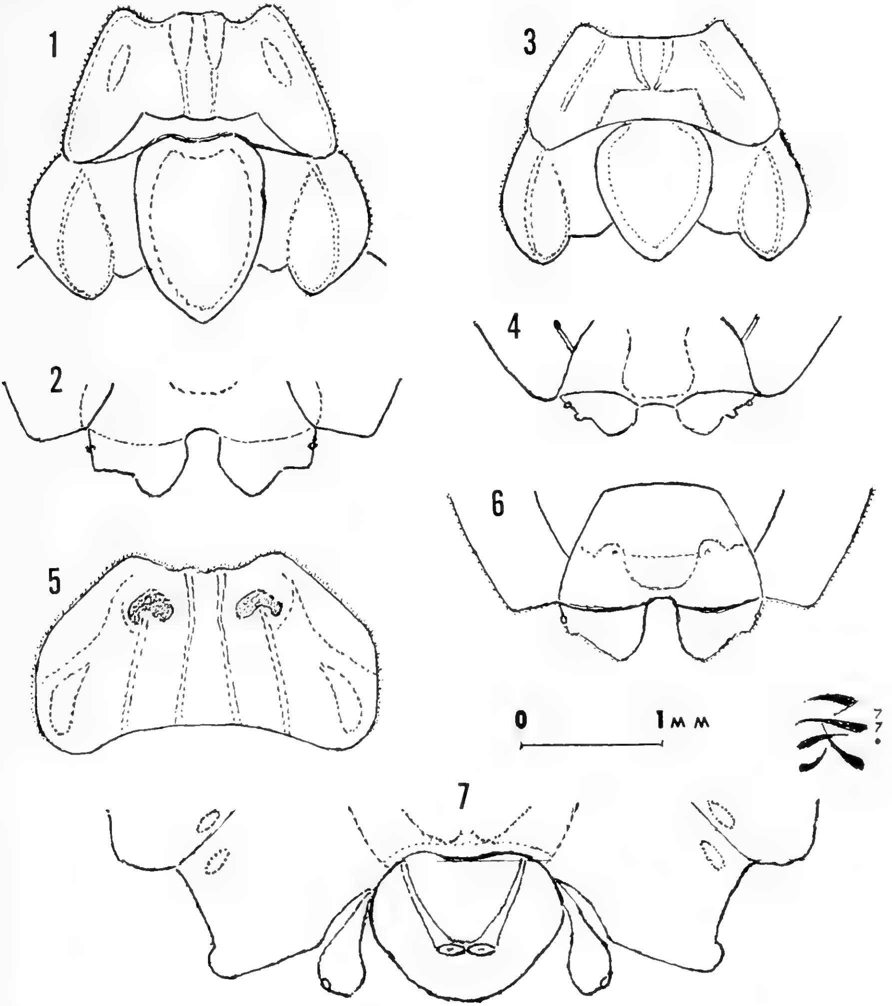
"Quilnus group" is characterized by the labium not extending beyond the fore border of the prosternum and by the straight lateral borders of the pronotum. It has so far only 10 species, of which three are from the Nearctic and 7 from the Palaearctic Region. I am now adding two new species from Oregon.

Aradus heidemanni Bergroth

Figs. 1–2

Aradus heidemanni Bergroth (1906) is rather common in Oregon and Northern California.

Measurements of a brachypterous female from Oregon: Head 33:33; relative length of antennal segments I–IV are 8:20:18:13; pronotum 17:50; scutellum 35:20; abdomen 125:105. Total length 7.80 mm; width of pronotum 2.00 mm; width of abdomen 4.20 mm.



Figs. 1–2. *Aradus heidemanni*, female. 1. Pronotum, scutellum and hemelytra; 2. Tip of abdomen from above. Figs. 3–4. *Aradus oregonicus*, female. 3. Pronotum, scutellum and hemelytra; 4. Tip of abdomen from above. Figs. 5–6. *Aradus usingeri*. 5. Pronotum; 6. Tip of abdomen from above. Fig. 7. *Eunotoplocoris ruckesi*, male, tip of abdomen from above.

Aradus oregonicus Kormilev, new species

Figs. 3–4

Description.—Female. Brachypterous.

Head: As long as its width across eyes (30:30); anterior process compressed laterally, reaching slightly beyond tip of antennal segment I; antenniferous tubercles acute, diverging, lateral tooth absent; postocular tooth minute, rounded. Antennae 1½× as long as width of head across eyes (45.5:30); antennal segment I obovate, II and III cylindrical, IV fusiform; relative length of antennal segments I–IV are 7.5:15:15:8. Labium reaching hind border of labial groove, which is closed posteriorly.

Pronotum: Trapezoidal, shorter than its maximum width (15:45); anterior angles produced forward and rounded; lateral borders straight, strongly converging and finely serrate; hind angles produced backward and rounded; hind border evenly sinuate between hind angles. Disc with median sulcus, flanked by 2 (1 + 1) short carinae, converging posteriorly, and further laterad by 2 (1 + 1) oblique carinae; depressed along posterior border medially.

Scutellum: Short, only slightly longer than its maximum width (25:20); lateral borders raised and rounded, tip narrowly rounded; disc depressed.

Hemelytra: Abbreviated, without membrane; corium reaching tip of scutellum.

Abdomen: Longer than its maximum width (95:86); postero-exterior angles of connexiva II–VI not protruding, but lateral border is notched at sutures between connexiva; postero-exterior angle VII is rounded. Genital lobes subtriangular, rounded at tip and with a small tubercle on exterior border.

Color: Black, dark brown on ventral side.

Size: Total length 6.64 mm; width of pronotum 1.80 mm; width of abdomen 3.44 mm.

Holotype.—Female (Entomological Museum, Oregon State University) Oregon, Linn Co., Lost Prairie, 3,800′; 38 mi E Sweethome; 29.VII.1958; J. D. Lattin leg.

Discussion.—*Aradus oregonicus* is closely related to *A. heidemanni* but is smaller; the antennae are relatively shorter, only 1.52× as long as width of head across eyes (1.78× in *A. heidemanni*); the lateral tooth is absent; the postocular tubercles are minute and rounded; the pronotum is less cut out posteriorly. Scutellum is relatively shorter, almost ovate, with rounded lateral borders. Lobes of VIII (genital lobes) are much shorter and are more rounded posteriorly; the incisure between them is shallow with ratio of depth of incisure to width of head across eyes as 5:30 (12:33 in *A. heidemanni*).

Aradus usingeri Kormilev, new species

Figs. 5–6

Description.—Female. Macropterous. Head, pronotum, scutellum, basolateral borders of corium and base of veins, connexiva, tergum VII and genital lobes, covered with short, erect, spiculoid granulation.

Head: Longer than its width across eyes (35:31); anterior process long, compressed laterally, reaching beyond base of antennal segment II; antenniferous tubercles acute, long, and slightly diverging, reaching ½ of antennal segment I. Lateral tooth absent; preocular tubercles minute, but distinct; postocular small, rounded. Vertex with 2 (1 + 1) black, callous spots, connected posteriorly and flanked by erect, spiculoid granulation. Antennae long, as thick as in *A. heidemanni*, 1.7× as long as width of head across eyes. Antennal segment I barrel-shaped, II and III cylindrical, IV fusiform; relative length of antennal segments I–IV are 7:18:16:12. Labium thin, reaching hind border of labial groove, which is open posteriorly.

Pronotum: Hexagonal, less than ½ as long as its maximum width (27:60); anterior border sinuate; anterolateral angles slightly produced forward, rounded; lateral borders parallel, converging anteriorly; hind angles rounded and slightly produced backward. Fore disc with 2 (1 + 1) horseshoe-shaped black callosities and with 4 (2 + 2) thin ridges, flanked posteriorly by 2 (1 + 1) short ridges.

Scutellum: Subtriangular, longer than its maximum width (41:30); lateral borders raised and slightly convex, tip rounded, disc depressed.

Hemelytra: Complete, reaching ½ of tergum VIII; corium reaching hind border of connexivum IV, clavus reaching tip of scutellum; basolateral borders of corium expanded, rounded and reflexed; apical angle acute, apical border convex forming 2 festoons; veins raised.

Abdomen: With subparallel, slightly convex sides, longer than its maximum width (100:90); posteroexterior angles of connexiva II–V not protruding, VI protruding, VII forming an obtuse angle. Lobes of VIII subtriangular, deeply cleft; ratio length of incisure to width of head across eyes as 12:31.

Color: Dark brown to black.

Size: Total length 8.28 mm; width of pronotum 2.40 mm; width of abdomen 3.60 mm.

Holotype.—Female (Entomological Museum, Oregon State University), Oregon, Corvalis, Benton Co., 14.IV.1958, on side walk; J. D. Lattin leg.

Etymology.—This species is dedicated to the memory of late Prof. Dr. Robert L. Usinger, who contributed so much to our knowledge of Aradidae.

Discussion.—*Aradus usingeri* is related to *A. heidemanni*. It belongs to the same "Quilnus group" as it has the labium not produced beyond the hind border of the head. It may be separated from the latter by being macropterous (females of *heidemanni* are brachypterous and males stenopterous), by having the pronotum hexagonal and not trapezoidal, by possessing differently shaped genital lobes, and by having curious, spiculoid granulation.

Subfamily MEZIRINAE

Genus *Eunotoplocoris* Kormilev

Eunotoplocoris ruckesi Kormilev

Fig. 7

Description.—Male. Head, pronotum and scutellum roughly granulate; central dorsal plate and connexivum roughly punctured; body covered with short, curled, rusty hairs; femora and antennal segments I–III with erect bristles. Micropterous.

Head: Shorter than its width across eyes (61:65); anterior process robust, slightly constricted at sides, genae produced far beyond clypeus and cleft, reaching ½ of antennal segment I. Antenniferous tubercles robust, dentiform, divaricating, reaching basal ¼ of antennal segment I. Eyes globose and slightly stalked. Postocular tubercles minute, by far not reaching outer borders of eyes; postocular borders behind them are long and converging in slightly arcuate line. Infraocular carinae low, crenulate; vertex raised and with a double row of granules. Antennae relatively thin, with exception of 1st segment, which is stout and fusiform; II subcylindrical, slightly enlarged apically and tapering at base; III cylindrical; IV is missing; relative length of antennal segments I–III is 40:25:37. Labium very short, reaching ½ of a deep labial groove, which is open posteriorly.

Pronotum: Much shorter than its maximum width across anterolateral lobes (26:82). Collar sinuate and granulate; anterior borders laterad of collar sinuate; anterolateral angles produced into winglike lobes, straight interiorly and rounded exteriorly, crenulate and produced far beyond collar. Lateral borders are narrower than anterolateral lobes (80:82), parallel between themselves; hind border evenly arcuate. Fore disc with a shallow median depression, flanked by 2 (1 + 1) flat, semicircular callosities, and further laterad by 2 (1 + 1) high, ovate ridges. Hind disc is greatly reduced to a narrow strip along hind border of pronotum, separated from fore disc by a thin, transverse sulcus.

Mesonotum: Subtriangular in the shape of a scutellum, shorter than its basal width (33:75), truncate posteriorly and raised medially, covered with very rough granulation.

Metanotum: Consisting of 2 (1 + 1) plates, separated by mesonotum, raised posteriorly and deeply depressed anteriorly.

Hemelytra: Reduced to small, elongate pads, placed laterad of mesonotum.

Abdomen: Subquadrate, longer than its maximum width across segment II or V (148:135); tergum I raised, convex anteriorly and sinuate posteriorly, separated from metanotum and tergum II by thin sulci. Tergum II much wider than tergum I, flat, separated from quadrate central dorsal plate and connexivum by thin sulci. Central dorsal plate consisting of terga III–VI fused together, it is raised medially and laterally, with 2 (1 + 1) rows of round, callous spots placed in depressions; laterad of them with 2 (1 + 1) rows of smaller, round, callous spots, also placed in depressions in zigzag pattern. Connexivum roundly produced at segment II; with parallel, but festooned borders from III–VI; converging at VII. Posteroexterior angles of connexiva from II–VI rounded and protruding; forming small, rounded and diverging lobes on VII. Scars of dorsal scent gland openings placed on terga IV and V posteriorly. Tergum VII raised for reception of a large hypopygium (25:33) with a flat, triangular, median ridge, and semicircular, biheaded ridge surrounding the latter. Paratergites clavate, reaching ⅘ of hypopygium. Spiracles ventral from II–VI and placed far from border, ventral, but placed near border on VII, lateral and visible from above on VIII. Metathoracic scent gland openings are large, gaping, slightly curved and visible from above.

Legs: Unarmed, arolia absent.

Color: Uniformly black.

Size: Total length 11.20 mm; width of pronotum 3.28 mm; width of abdomen 5.40 mm.

Material.—Male (Instituto de Biologia UNAM, Mexico City, Mexico), Peru, Cuzco; P. Reyes leg.

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Research Associate in Entomology, Bishop Museum, Honolulu, Hawaii 96818 (mailing address: 84-05 89th Street, Woodhaven, New York 11421).

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DEFENDED HUNTING TERRITORIES AND HUNTING BEHAVIOR OF FEMALES OF *PHILANTHUS GIBBOSUS* (HYMENOPTERA: SPHECIDAE)

Norman Lin

Abstract.—Females of the solitary wasp *Philanthus gibbosus* (F.) defend hunting territories around the particular halictine bee nests they hunt at, against conspecific females. Halictine bee prey may be taken from within the nest or outside the bee nest when bees leave or return to their nests.

Among birds, the females of most species have no territories of their own, rather they adopt the territory of their mate and aid in the defense of his territory. Also rare are birds which defend territories solely around specific food sources such as the hummingbird which may abandon a flowery shrub, which it had previously defended, when the blossoms fall. Thus territory is abandoned when food supply fails (Klopfer, 1969). As described in the present study, females of the digger wasp, *Philanthus gibbosus* (Fabricius), are at present apparently unique among hymenoptera, if not territorial organisms in general, in defending individual territories about the future food supply of their young from conspecific females.

While the life history and behavior of *P. gibbosus* is in general better known than any other species of the genus, there are still many major gaps in our knowledge. Reinhard (1924) reported halictid bee prey being taken at flowers, and Alcock (1974) obtained indirect evidence of such hunting by observing females flying from flower to flower and in one case noted a female carrying a halicitid and a tufted dandelion seed which he believed indicated the capture was made on a flower. In other areas he observed bees taken at a large halicitid colony. Peckham and Peckham (1905) reported that the wasps took guard bees indicating that captures also occur near or on the ground; Evans and Lin (1959) observed one female of *P. gibbosus*, in the course of 10 minutes, enter the nest of an unidentified halictine bee four times and each time came out with a bee she took to her own nest. The most common prey species they noted was *Lasioglossum zephyrum* (Smith), there being 15 specimens. *Augochlora pura* (Say) was one of the least common species, there being three specimens. They conducted their study in Ithaca, New York. Barrows and Snyder (1973) studied the contents of 15 cells provisioned by *Philanthus gibbosus* in a vertical bank containing nest aggregations of *Lasioglossum zephyrum* located in Douglas County, Kansas. They found that eight species of halictine bees were used and *L. zephyrum* was one of the three species represented by only one specimen. This in contrast with the 53 specimens of *Augochlora pura*, the most commonly encountered species. They concluded that the wasp did not hunt near their nest and did not enter *Lasioglossum zephyrum* burrows to capture prey. They further suggested that perhaps *Philanthus gibbosus* hunts primarily around flowers as do *P. triangulum* (Fabricius) (Tinbergen, 1932) *P. politus* Say (Evans and Lin, 1959) and *P. bicinctus* (Mickel) (Armitage, 1965).

Alcock (1974) studied an aggregation of *P. crabroniformis* Smith in a lot in Seattle, Washington. A smaller aggregation of *P. gibbosus* was interspersed in this aggregation. He reported that *P. crabroniformis* primarily captured bees by striking them in flight as they returned to their nest, and he placed his major emphasis on this method of bee capture which has not previously been investigated in *P. gibbosus* and is unknown in the literature of *P. gibbosus.*

General Characteristics of Hunting Behavior

Hunting behavior of *P. gibbosus* was studied intensively during the active season in the vicinity of a vertical sandbank in which numbers of both wasps and an unidentified halictine bee nested in number. On 30 August between 10:54 AM and 5:36 PM observations were made, barring a few absences of usually less than an hour, of the attacks by wasps on the 8 marked, and by far most frequently attacked bee nests (A to H) on the sandhill. Not all attacks were observed due to the temporary absences and since observations on other aspects of behavior were being studied simultaneously. However the representation is an accurate one since similar observations were made all summer during the active season of the wasp. The only failing is that on this particular date the wasps were unsuccessful in capturing even a single bee. However all attacks were made at the nest entrance whether guarded or not, and wasps, frequently unsuccessful at one nest, went from nest to nest and occasionally a wasp entered an unguarded nest and withdrew without prey. Experience has shown that by far the most successful attacks are made against bees assuming flight in leaving their nests or on their return to their nests, attacks not observed to occur on this date. However in the past bees were observed being taken from within the nest. A total of 63 attacks were observed to have been made at the entrance of bee nests, whether guarded or not. In attacking, wasps palpitate the head of the guard or the empty nest entrance with their antenna; and when the guard blocks the entrance with its abdomen, wasps have been observed attempting to grasp the bee by the abdomen with their mandibles and to pull it out. They also on occasion vigorously engage in biting away at the walls of the guarded nest entrance in attempts to gain entry. There were four distinct episodes in which wasps entered an unguarded bee nest. All occurred in nest A which had the largest entrance of all 8 nests. In one case a wasp entered nest A six times, each time coming out in seconds. The same was repeated two times by presumably another wasp.

On 25 September a rather large halictine bee was caught in midflight by a female *P. gibbosus*. The bee was caught in the vicinity of the bee nest area where other bees were hovering in flight. On capture the pair fell approximately six inches to the slope below and the wasp was seen to have its sting pushed up against the bee and definitely appeared to sting the bee. The wasp then picked up the bee and flew approximately 7 feet to enter its nest in the slope. Another mid-air attempt at capture by another wasp failed and the bee then took evasive zig-zag flight. Such unsuccessful mid-air capture is a common occurrence.

On 3 September a female *P. gibbosus* was on the slope, and a number of halictine bees were flying around. One bee flew near the wasp approximately 4 inches over the ground. The wasp pounced on the bee, malaxated it and brought the tip of her abdomen up to it in what was a probable stinging effort; and in about three seconds flew off with the bee. On 3 September in another instance a halictine bee flew about 2 inches over the slope and a *P. gibbosus* flew up and pounced on her and the two fell, locked together, to the slope and rolled down the slope for approximately 4 inches; and after about 4 seconds from the time of capture, the wasp flew off with the bee. The wasp did appear to malaxite the bee and also I believe it had the tip of its abdomen in probable stinging behavior pressed against the bee. On 28 August a number of successful captures of guards were made at nest A, the nest with the largest entrance which permitted the entry of all but the larger female wasps.

A wasp probed at a halictine bee nest entrance and palpated the head of the guard with her antennae. The guard turned to block the entrance with her abdomen and the wasp soon left. Another wasp suddenly grabbed a small bee on the outside of her nest and seemed to malaxite it approximately 10 seconds and to fly off with it; and though it had curved its abdomen up to the stinging position, it appeared that it did not actually sting the bee. A few minutes later a wasp was seen to enter nest A. The female *P. gibbosus* was small enough to enter. This is only one case of the individual differences in hunting techniques among female *P. gibbosus*. Others involved waiting for returning bees at their nests, pouncing at bees leaving their nests, making mid-air captures and hunting at flowers or elsewhere as an individual habit. The territories, to be discussed, briefly mention that individual wasps have favorite nests around which they hunt. A wasp entered nest A, and a minute later a wasp entered the same nest and squeezed approximately half way in and pulled a guard out and seemed to malaxite it a few seconds and then immediately flew off with it. I definitely believe this bee was not stung. This nest immediately had a new guard in its absence. In a few minutes a wasp entered nest A and in seconds pulled out a bee, malaxited it a few seconds and flew with it to its nearby nest in the same sand slope. Immediate stinging in *P. gibbosus* is often far from the rule. I have, on a number of occasions, caused a wasp to drop a bee she was carrying in flight to her nest; and, on being dropped, the bee proved to be uninjured, recovered and flew away.

General Characteristics of Hunting Territories

Females in flight over their vertical bank hunting and nesting area behave entirely differently toward other females below in the area in comparison to females located below them in the nesting aggregation of an open field in Brooklyn where the nests of bees are not close by their prey nests. A female coming on another female even as much as 2 feet away and the latter at a bee nest on the slope of her hunting area pounces upon the latter and either chases her off of they both fly off or the pouncer flies off. The latter much in the manner of territorial male cicada killer wasps perching in their territory being pounced on by rival males and almost invariably pursuing the rival male which pounced on the owner (Lin, 1963) or the same may be observed among territorial males of *Polistes exclamans* Viereck (Lin, 1972). Females even pursue other females in the air. The following instance represents a case seemingly identical to two territorial male cicada killer wasps which, both being over their own territory, fly aggressively at each other and grapple (Lin, 1963). Two females engaged in hunting behavior were flying inches over the slope and after about 5 seconds came close to each other and when a few inches apart flew at each other, met in mid-air, grappled, fell to the sand below, continued to wrestle for about a second or two, separated and both flew off. In another instance a female wasp was probing nest G when a second female flew toward G and the first female flew up and made contact with the intruder when the latter was approximately 2 inches from G. The argument might be made that females attacking other females are acting toward them as bee prey rather than territorial rivals. Reasons have already been cited making this most unlikely; one further reason involves the response of a female to a male which is nearly identical in appearance to the female. A male was on the mound of a nest which it had just closed, and it began flight. A female was engaged in hunting and was at the entrance of nest A. She spied the slow flying male and flew at the male but she did not hit him as she obviously would have done to a female; (but apparently recognized him as a male probably by chemical means) she continued to fly toward him but when approximately one inch from the male she broke off the pursuit without making contact.

Also recorded on 30 August were the number of aggressive attacks by one female at another or mutual attacks, the minimum of these were 26 between 2:06 AM and 5:26 PM with some large time lapses when the observer was not present or when his attention was directed in recording other aspects of behavior. At 3:51 PM in about one 3-minute period, four aggressive female encounters occurred including chasing in the air, pouncing on the ground, and several wrestlings. So much female-female aggressive behavior occurred in that brief span because as many as four females were hunting at the same time in the small area of the vertical bank. At 4:06 PM much the same occurred, four females were hunting at the same time (at 4:12 PM five females were hunting at the same time and at 4:34 PM six females were similarly engaged), and I believe I observed greater hunting activity than I ever saw at any other time and also far more female aggressiveness than ever before. I didn't even record the number of encounters but certainly there were in that space of minutes at least five and probably closer to eight. I believe that during this time of day the highest frequency of hunting behavior and female *P. gibbosus* territorial aggressive behavior occurs. This might in fact be what is to be anticipated since it is probably the time when the bees return to their nest for the day after gathering pollen; it is also the time of day that the territorial females of *Philanthus gibbosus* "wait" for them around their favorite bee nests in their territories.

One medium or medium large female was marked with paint on 4 September. This was female 2. Female 2 was observed almost daily from 4–14 September in the vicinity of her hunting territory where she particularly localized around bee nest H which she often sat next to or attacked the guards in the entrance or pursued some passing bee in flight to or from the nest. She vigorously defended a territory about 2 square feet encompassing this area.

Discussion

Long term studies of *P. gibbosus* have revealed that 1972 was a year of exceedingly large populations of these wasps in Brooklyn. Halictine bees were also extremely common during that year. While untrue in other years, the major source of halictid bee mortality in the Brooklyn areas studied was due to the predation of *P. gibbosus* (for a comparison of the causes of halictine bee mortality in previous years in Brooklyn see Lin, 1964 and 1964–65). Hunting territories among *P. gibbosus* females was never observed in the large 40 acre field in Brooklyn (1956–1976) where years of data were gathered but was observed in the crowded conditions in a vertical bank in 1972 also in Brooklyn where both wasps and an unidentified species of halictine bee nested in large numbers.

Hunting territories probably arise under conditions of dense *P. gibbosus* populations when they are located in banks which also house the nests of halictine bees. A safe prediction is that such territories do not exist in large fields where intensive observation over the years has failed to reveal any female-female aggression other than that associated with encroachment by one female of another female's nest where prey species of bees are probably taken at flowers or dispersed nests. In years when *P. gibbosus* is scarce, hunting territories are probably nonexistent over banks inhabited by both wasps and halictine bees, especially should the latter be in excessive amount. This may be the explanation for the findings of Barrows and Synder (1973) that *Lasioglossum zephyrum* was abundant in the nesting banks of *Philanthus gibbosus* and that the wasps apparently did not hunt near their nest which suggested that competition for prey was not great. Only prey shortage or predator abundance or both under these conditions may elicit territorial behavior.

Hunting territories in other digger wasps are here postulated to be uncommon due to the transitory nature of the location of their food supply as opposed to a rigidly fixed source in *Philanthus* provided by the permanent bee nests located in a small concentrated area of a bank or elsewhere in the current case.

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1487 East 37th Street, Brooklyn, New York 11234.

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A NEW GENUS AND TWO NEW SPECIES OF ASTEROLECANIID SCALE INSECTS ON PALM FROM COLOMBIA AND TRINIDAD (HOMOPTERA: COCCOIDEA: ASTEROLECANIIDAE)

Douglass R. Miller and Paris L. Lambdin

Abstract.—A new genus, *Grammococcus*, and two new species, *G. adetocorymbus* and *G. corymbus*, are described and illustrated. Affinities and a diagnosis of the genus are also provided.

A new genus is described for two new species of unusual palm inhabiting asterolecaniid scale insects. Because both species were found in large populations on their hosts and because palms are frequently grown as ornamentals in the United States, we felt that it was important to describe these potential pest species.

Methods and Depositories

Numbers and measurements were taken from 10 specimens and are the average rounded off to the nearest whole number followed by the range in parentheses. Measurements are given in microns.

Specimens are deposited in: British Museum (Natural History), London (BM); California Department of Agriculture, Sacramento (CDA); Florida State Collection of Arthropods, Gainesville (FSCA); Museo de Historia Natural de la Ciudad de Mexico, Mexico City (MNC); Museum National d'Histoire Naturelle, Paris (MNHN); South African National Collection of Insects, Pretoria (SA); University of California, Davis (UCD); The University of Tennessee, Knoxville (UT); U.S. National Museum of Natural History, Washington, D.C. (USNM); Virginia Polytechnic Institute and State University, Blacksburg (VPI); and Zoological Institute, Academy of Sciences of USSR, Leningrad (ZI).

Grammococcus Miller and Lambdin, new genus

Type-species.—*Grammococcus adetocorymbus* Miller and Lambdin, new species.

Type-locality.—St. Clair, Port-of-Spain, Trinidad.

Affinities.—*Grammococcus* appears to be closely related to *Polea* Green. Similarities shared by adult females in the two genera are: Lack of large 8-shaped pores on submargin, presence of submarginal pore clusters, irregularly spaced minute 8-shaped pores on dorsum and bilocular pores clustered about mouth parts on venter. *Grammococcus* may be separated from *Polea* by the structure of the anal ring, the type of pores in the submarginal pore clusters on the dorsum, the trilocular pores laterad of the spiracles, the number of labial setae, the reduced number of transverse rows of multilocular pores, and the lack of a submarginal band of quinquelocular pores on the venter. For a detailed treatment of *Polea* see Lambdin (1977).

Etymology.—The generic name is from the Greek *gramme* meaning "line" and *coccus* (latinized) meaning "seed or scale insect." The name refers to the lines of dorsal tubular ducts characteristic of this genus.

Third-Instar Females (Adult)

Diagnosis.—Quinquelocular pores in clusters on dorsosubmargin, large 8-shaped pores absent, minute 8-shaped pores and simple pores present, tubular ducts in 2 longitudinal lines on each side of body. Venter with unsegmented antennae, bilocular pores near mouthparts, legs absent, trilocular pores near spiracle, multilocular pores in 2 or 3 transverse rows near vulva and submarginal 8-shaped pores in a submarginal row.

Adult females differ from other instars by the following combination: With a vulva, unsegmented antennae, ventral multilocular pores, dorsal tubular ducts, dorsal pore clusters, minute 8-shaped pores, row of trilocular pores in each spiracular furrow and bilocular pores; without legs, marginal 8-shaped pores and dorsal multilocular pores. Adult females are similar to the 2nd-instar males but are separated by having a vulva, spiracular furrows and multilocular pores.

Second-Instar Females

Diagnosis.—Dorsosubmargin with quinquelocular pores in clusters, large 8-shaped pores in medial area, simple disc pores irregularly spaced, tubular ducts absent. Venter with bilocular pores, minute 8-shaped pores, and pores near spiracles absent, antennae unsegmented, submarginal 8-shaped pores extending from cephalothorax to posterior abdominal segments.

Second-instar females differ from other instars by the following combination of characters: Without a vulva, dorsal and ventral multilocular pores, dorsal tubular ducts, minute 8-shaped pores, spiracular pores, marginal 8-shaped pores, legs and bilocular pores; with dorsal pore clusters and 2 medial rows of large 8-shaped pores. Second-instar females are similar to 2nd-instar males but differ by lacking dorsal tubular ducts, minute 8-shaped pores and bilocular pores.

First Instars

Diagnosis.—Dorsum with 2 pairs of multilocular pores, 8-shaped pores in medial and submarginal areas, simple disc pores. Venter with submarginal tubular ducts, legs with trochanter and femur fused, antennae segmented.

First instars differ from other instars by the following combination of characters: With 2 pairs of dorsal multilocular pores, legs, segmented antennae, marginal and submedial rows of large 8-shaped pores and a trilocular pore near each spiracle; without a vulva, ventral multilocular pores, submarginal 8-shaped pores, dorsal tubular ducts, dorsal pore clusters and bilocular pores. Well-developed legs separate 1st instars from all others except 3rd to 5th-instar males which have either wing buds or wings.

Fifth-Instar Males (Adult)

Diagnosis.—Penial sheath short (Fig. 4), with 2 pairs of eyes, antennae 9-segmented, reticulate pattern on several areas of head and thorax.

Fifth-instar males differ from other instars by having a well-developed penial sheath, sclerotized thorax, 2 pairs of eyes, and 9-segmented antennae; by lacking mouthparts, pores and ducts. Fully developed wings immediately separate adult males from other instars.

Fourth-Instar Males (Pupae)

Diagnosis.—Pores and ducts absent, antennae 9-segmented, legs 6-segmented, dermal nodules on dorsum.

Fourth-instar males differ from other instars by the following combination of characters: With 9-segmented antennae, 6-segmented legs, wing buds and dermal nodules; without pores, ducts and mouthparts. Fourth-instar males differ from 3rd-instar males by the latter's having 8-segmented antennae and 4-segmented legs.

Third-Instar Males (Prepupae)

Diagnosis.—Pores and ducts absent, antennae 8-segmented, legs 4-segmented, dermal nodules on dorsum.

Third-instar males can be distinguished from all other instars by having characters given in diagnosis and by lacking pores, ducts, and mouthparts. Third-instar males differ from 4th instar males by the latter's having 9-segmented antennae and 6-segmented legs.

Second-Instar Males

Diagnosis.—Dorsum with clusters of quinquelocular pores on submargin, 8-shaped pores in medial area, minute 8-shaped pores and simple disc pores. Venter with unsegmented antennae, bilocular pores near mouthparts, pores absent near spiracles and 8-shaped pores in submarginal band. Similar morphologically to adult female but distinguished by absence of vulva, spiracular furrows and multilocular pores.

Second-instar males differ from other instars by the following combination of characters: With dorsal tubular ducts, minute 8-shaped pores, unsegmented antennae and bilocular pores; without a vulva, dorsal and ventral multilocular pores, spiracular pores, marginal 8-shaped pores and legs. Second-instar males are similar to 2nd-instar females but differ by having dorsal tubular ducts, minute 8-shaped pores and bilocular pores.

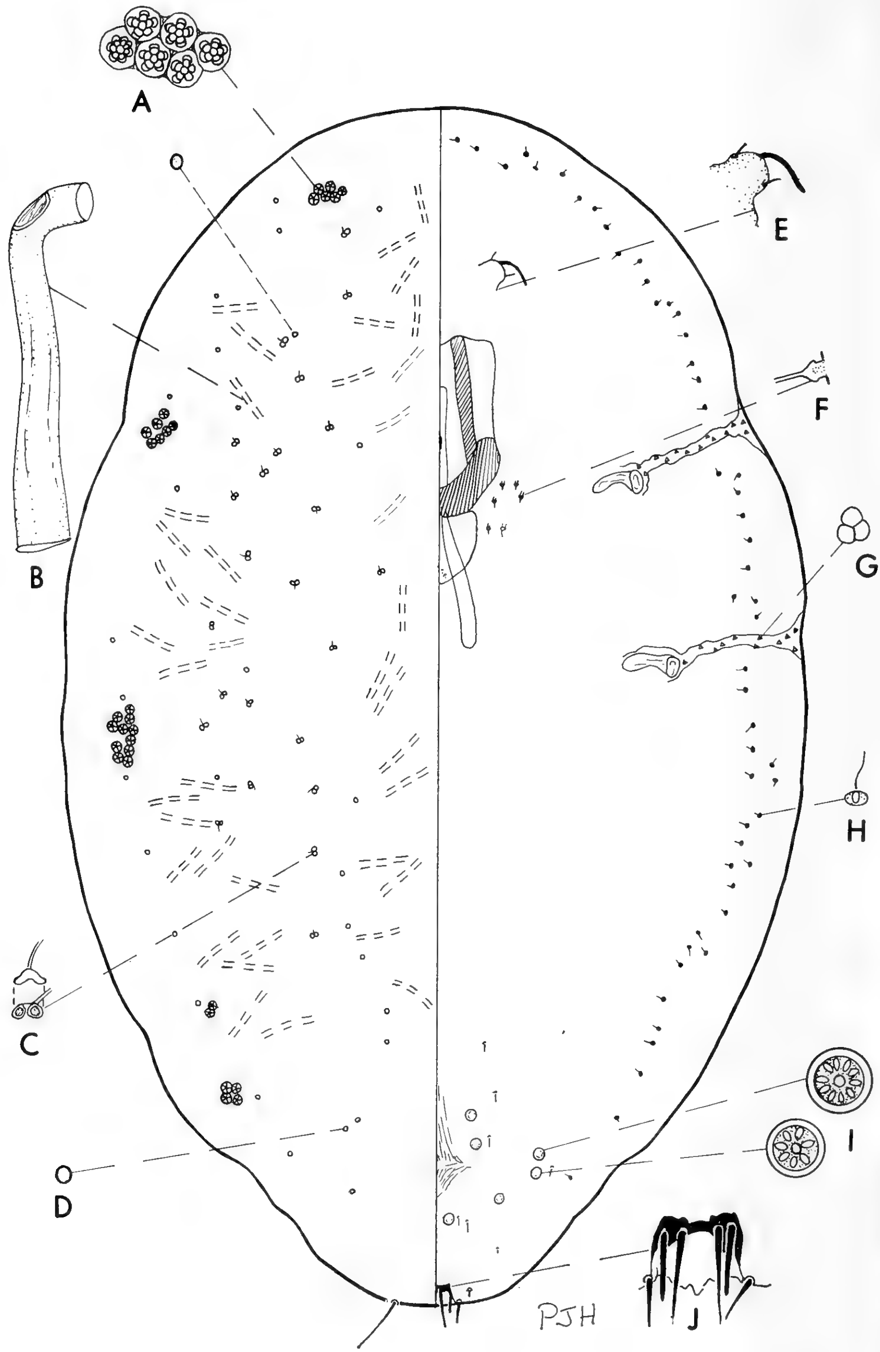
Grammococcus adetocorymbus Miller and Lambdin, new species
Third-Instar Females (Adult)
Fig. 1

Type material.—Holotype adult female on slide with 31 other specimens: Left label, "*Grammococcus adetocorymbus* Miller and Lambdin, Holotype, Paratypes; on palm, Dept. Agr. Grounds, St. Clair, Port-of-Spain A-1035 Trinidad, Nov. 22–18, H. Morrison"; right label gives map of specimens on slide, locates position of holotype and states "Holotype, Paratype." There are 368 paratypes mounted on 30 slides with the same data as the holotype. Holotype and several paratypes are deposited in USNM; 1 paratype slide is deposited in each of the following: BM, CDA, FSCA, MNC, MNHN, SA, UCD, UT, VPI and ZI.

Field features.—Occurring on foliage, apparently abundant.

Body measurements.—Holotype mounted, 561 long (paratypes 683 (549–830)), 354 wide (paratypes 529 (342–639)).

Dorsum.—Longest anal-lobe seta 33 long (paratypes 31 (23–35)); seta mesad of longest seta normally touching anal-ring sclerotization, 10 long (paratypes 11 (9–13)); other dermal setae absent. Large 8-shaped pores normally absent, present on 8 of 100 randomly selected specimens, presumed part of exuviae of previous instar. Minute 8-shaped pores irregularly scattered, about 2 long. Simple disc pores forming 2 pairs of irregular longitudinal lines, about 30 on each side of body. Paired, simple disc pores absent. Pore clusters loose, not as compact as on 2nd instar, frequently with spaces between pores (posterior 2 clusters scattered), pores primarily quinquelocular. Number of quinquelocular pores in clusters; 6–7 pores in each anterior, cephalothoracic cluster (paratypes 6 (2–12)); 7–8 pores in each posterior, cephalothoracic cluster (paratypes 7 (4–14)); 11 and 12 in each anterior, abdominal cluster (paratypes 12 (8–18)); and 5 and 6 in each posterior, abdominal cluster (paratypes 9 (4–14)); 32 and 30 quinquelocular pores on each side of body (paratypes 35 (21–51)). Tubular ducts arranged in 2 pairs of longitudinal rows, 1 pair submedial and 1 pair mediolateral;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40 and 46 on each side of body (paratypes 50 (41–66)); longest duct 33 long (paratypes 35 (23–43)).

Venter.—Antennae 10 long (paratypes 10 (8–13)); each with 1 long, fleshy seta and 2 short, slender setae. Clypeolabral shield 90 long (paratypes 94 (88–105)), 63 wide (paratypes 68 (63–75)). Labium nearly square, 40 long (paratypes 41 (38–48)), 40 wide (paratypes 44 (40–50)); with 2 pairs of minute setae. Setae in transverse rows on posterior abdominal segments. Spiracles with associated trilocular pores in spiracular furrow from spiracle to body margin, 10 and 16 pores in posterior furrows (paratypes 12 (9–14)). Bilocular pores laterad of mouthparts near junction of labium and clypeolabral shield, 6 and 7 pores on each side of shield (paratypes 7 (5–9)). Submarginal 8-shaped pores arranged in band extending from anterior of antennae to abdominal segment VIII or IX, 40 and 52 on each side of body (paratypes 52 (37–62)). Multilocular pores normally 10-locular, rarely 9-, 8-, or 7-locular; 13 pores (paratypes 12 (9–13)) on abdominal segments VI–VIII. Anal ring "C" shaped, lateral sclerotized areas without central clear area, lateral sclerotizations joined by anterior sclerotized bar; 2 pairs of robust setae of equal length, about 20 long (paratypes 21 (18–23)).

Variation.—The paratypes normally have the dorsal clusters of quinquelocular pores more scattered than on the holotype; the antennal setae vary, some antennae have 2 fleshy setae and 1 thin seta, some have 1 thin, long seta, 1 thin, short seta, and 1 fleshy seta; pores in the spiracular furrows occasionally have 4 or 5 loculi.

Notes.—The above description is based on 182 specimens. The adult female of *G. adetocorymbus* differs from *G. corymbus* by having the lateral areas of the anal ring connected anteriorly by a thin sclerotized bar, dorsal clusters of quinquelocular pores, frequently with spaces between the pores, 7 (5–9) bilocular pores, and 52 (37–62) submarginal 8-shaped pores. *Grammococcus corymbus* differs by having the lateral areas of the anal ring separate, not connected by a sclerotized bar, dorsal clusters of quinquelocular pores with pores closely appressed, without spaces between the pores, 11 (9–14) bilocular pores, and 31 (24–36) submarginal 8-shaped pores.

Etymology.—The species epithet is from the Greek *adetos* meaning "unbound or loose" and *korymbos* meaning "cluster of flowers." The name refers to the loose clusters of flowerlike pores typical of this taxon.

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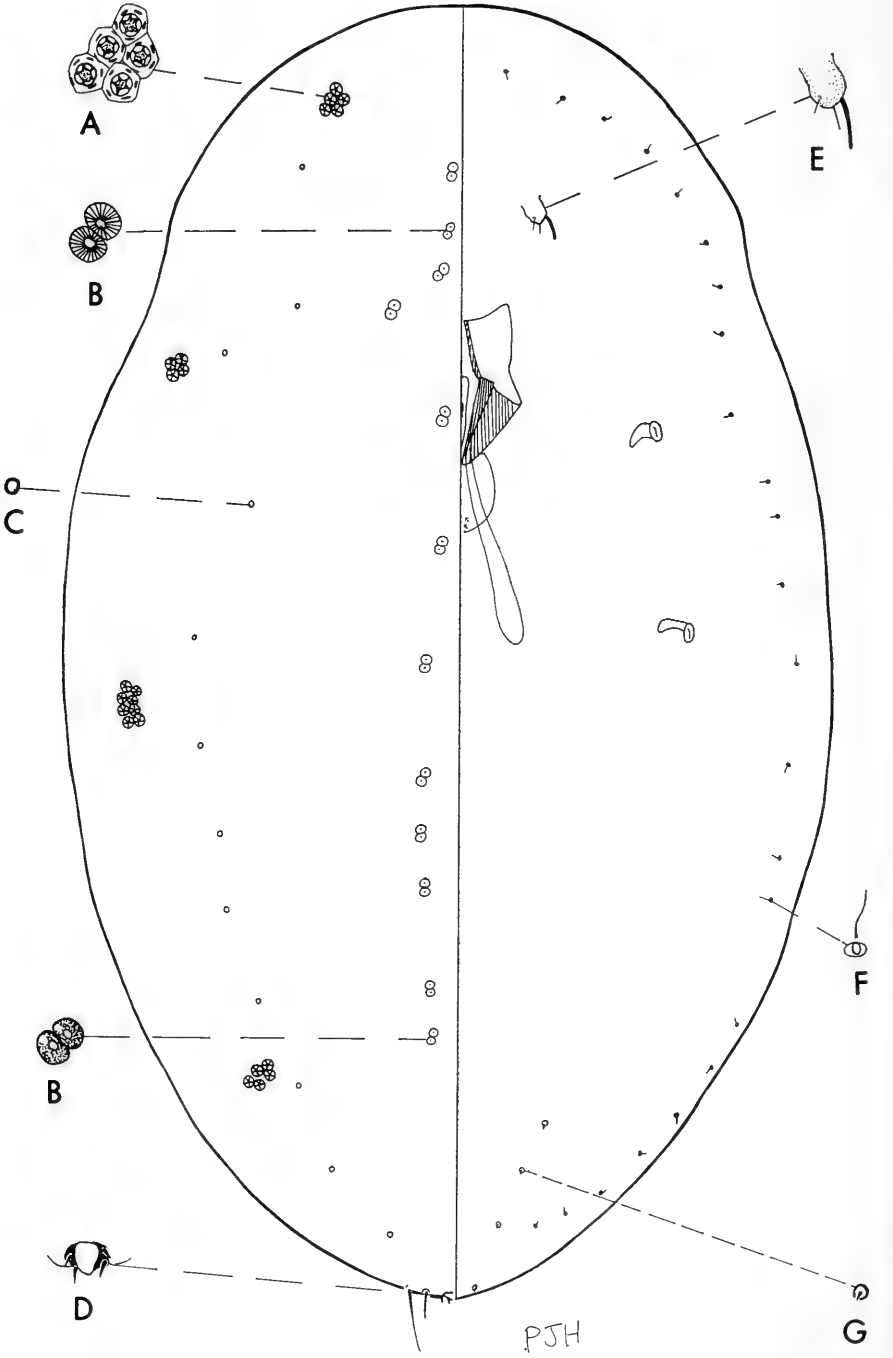
Fig. 1. *Grammococcus adetocorymbus*, adult female. A, cluster of quinquelocular pores; B, tubular duct; C, minute 8-shaped pore; D, simple disc pore; E, antenna; F, bilocular pore; G, trilocular pore; H, submarginal 8-shaped pore; I, multilocular pores; J, anal ring.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Second-Instar Females
Fig. 2

Body measurements.—Mounted, 473 (397–591) long, 286 (226–366) wide.

Dorsum.—Longest anal-lobe seta 29 (25–33) long; seta mesad of longest seta 7 (5–8) long; other dermal setae absent. Anal ring normally composed of 2 lateral, sclerotized pieces joined posteriorly and/or anteriorly by thin sclerotized area, each lateral piece with 2 minute setae 3 (2–4) long. Large 8-shaped pores, when present, in 2 longitudinal rows on submedial area of dorsum, each line with about 12 pores; number of pores variable, apparently part or all may slough off during moulting process possibly due to presence of fungus mycelia; largest pore on each specimen 11 (10–12) long, 7 (7–8) wide; smallest pore 8 (7–8) long, 5 (5–6) wide. Simple disc pores forming mediolateral, longitudinal row on each side of body; 11 or 12 in each line. Paired, simple disc pores absent. Pore clusters compact, clusters of quinquelocular pores normally located as illustrated; 6 (2–10) pores in each anterior, cephalothoracic cluster; 4 (2–6) pores in each posterior, cephalothoracic cluster; 5 (3–9) in each anterior abdominal cluster; and 5 (3–7) quinquelocular pores in each posterior abdominal cluster; 20 (11–30) pores on each side of body.

Venter.—Antennae 9 (8–12) long; each with 1 long, fleshy seta and 2 short, slender setae. Clypeolabral shield 72 (65–80) long, 56 (53–63) wide. Labium nearly rectangular, 37 (35–38) long, 34 (33–38) wide; with 2 pairs of minute setae. Setae forming submedial, longitudinal line on posterior 2–4 segments and an occasional marginal line on last 1 or 2 segments. Submarginal 8-shaped pores represented by 21 (18–24) on each side of body. Anal ring normally composed of small anterior and/or posterior bar connecting lateral areas, ring with 2 pairs of setae.

Notes.—The above description is based on 46 specimens. Second-instar females of *G. adetocorymbus* and *G. corymbus* are very similar. The anal ring of *G. adetocorymbus* has 2 pairs of setae and normally a small anterior and/or posterior sclerotized bar connecting the lateral areas. On *G. corymbus* the anal ring lacks setae and sclerotized bars connecting the lateral areas. Also, simple pores are restricted to thoracic region in *G. corymbus* while they are arranged in mediolateral longitudinal lines extending from the anterior area of head to the anal lobes in *G. adetocorymbus.*

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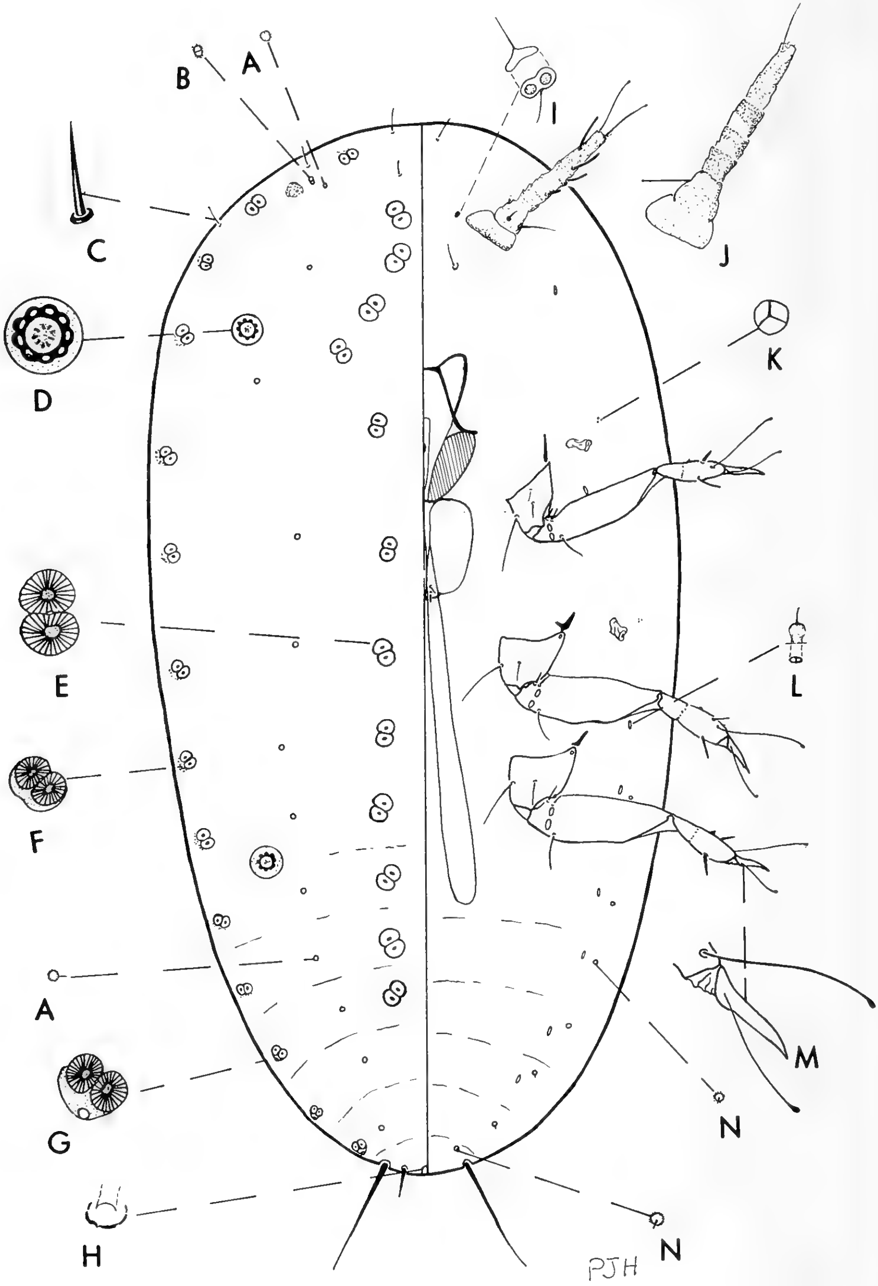
Fig. 2. *Grammococcus adetocorymbus*, second-instar female. A, cluster of quinquelocular pores; B, large 8-shaped pore; C, simple disc pore; D, anal ring; E, antenna; F, submarginal 8-shaped pore; G, seta.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First Instars

Fig. 3

We have been unable to separate 1st instars of G. *adetocorymbus* and G. *corymbus* and have included only one description.

Body measurements.—Mounted, 329 (293–360) long, 157 (140–183) wide.

Dorsum.—Longest anal-lobe seta 31 (30–33) long, seta mesad of longest seta 9 (8–13) long. Normally 3 marginal and 1 medial setae on each side of head. Anal ring variable, normally crescent shaped and without setae (of 70 specimens, 3 possessed anal-ring setae, all of G. *adetocorymbus*), some specimens without crescent-shaped sclerotization. Eyes slightly sclerotized. Large 8-shaped pores arranged in longitudinal lines: Marginal lines each composed of 14 pores, each pore with adjacent sclerotized area, posterior 3 pores with associated simple pore near adjacent sclerotized area; submedial rows each composed of 11 (7–13) pores, without adjacent sclerotized areas. Simple disc pores forming 1 mediolateral line on each side of body, 11 or 12 pores in each line. One paired simple disc pore anterior of each eye near body margin. Multilocular pores on mediolateral area of each side of body; anterior pair of pores near junction of head and thorax, posterior pair on intersegmental line between segments III and IV; each pore with 9 or 11 loculi, 9 (8–10) in diameter.

Venter.—Antennal segmentation unclear, apparently 6-segmented, 48 (45–52) long; setae normally as on Fig. 3, occasionally fleshy seta absent on subapical segment. Clypeolabral shield 52 (48–55) long, 39 (37–42) wide. Labium nearly rectangular, 29 (26–32) long, 31 (29–36) wide. Legs with trochanter and femur fused; tibia and tarsus fused or separated by weak line; tarsus with deltoid sensilla near junction of tibia and tarsus; tarsal and claw digitules capitate, extending beyond tip of claw; claw without denticle. Setae rare, 1 medial seta near antennal base, 6 or 7 minute setae forming submarginal, longitudinal line on abdomen. Spiracle with 1 associated trilocular pore. Submarginal tubular ducts arranged in a longitudinal line on each side of body, 8 in each line; submarginal 8-shaped pores represented by 1 pore near base of each antenna.

Notes.—The above description is based on 68 specimens of G. *adetocorymbus* and 2 of G. *corymbus*.

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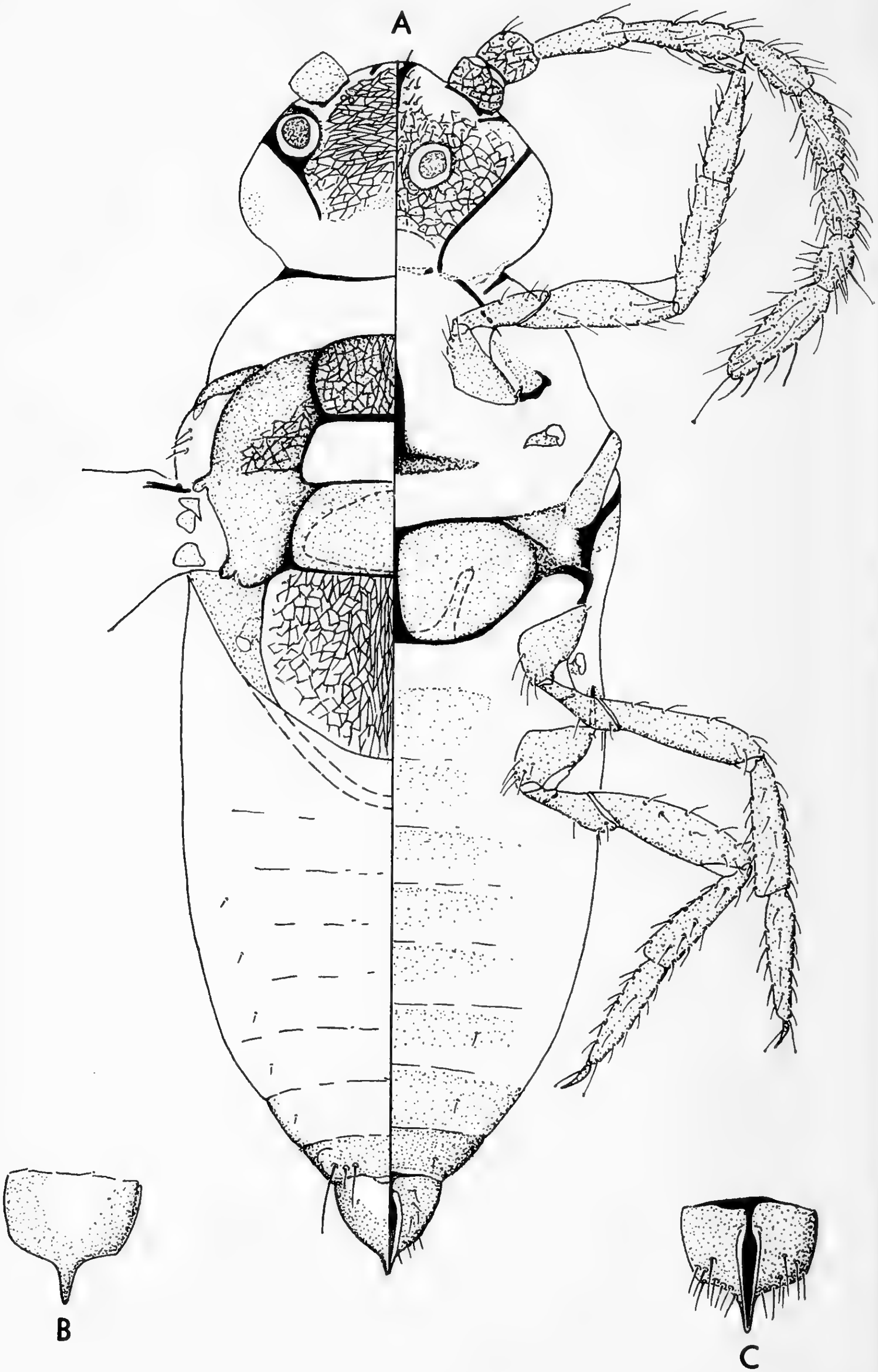
Fig. 3. *Grammococcus adetocorymbus* and G. *corymbus*, first instar. A, simple disc pore; B, paired simple disc pores; C, seta; D, multilocular pore; E, large 8-shaped pore; F, large 8-shaped pore with adjacent sclerotized area; G, large 8-shaped pore with associated simple disc pore; H, anal ring; I, submarginal 8-shaped pore; J, antenna; K, trilocular pore; L, submarginal tubular duct; M, tarsal claw; N, seta.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Fifth-Instar Males (Adult)
Fig. 4a

Body measurements.—Mounted, 689 (647–738) long, 298 (262–329) wide.

Description.—Dorsum with several hairlike setae in each tegular area, single seta in sublateral area of segments III, IV, or V–VII, 2 or 3 setae in each sublateral area of segment VIII. Ventrally setae on ocular sclerite anterior of ventral eye forward to lateral arm of midcranial ridge, and on mediolateral area of abdominal segments IV or V–VII. Penial sheath with setae scattered near ventral slit, setae absent dorsally.

Head subcircular; midcranial ridge with lateral and ventral arms, ventral arm extending from lateral arms to level of preocular ridge. Preocular ridge short, extending from dorsal eye to articulatory process of antenna. Postocular ridge well developed, originating near postoccipital sclerotization dorsally, extending to posterior margin of head ventrally. Postoccipital ridge weakly sclerotized or absent. Ocular sclerites and genae weakly sclerotized. Dorsal head pores 4 (1–7), near base of each antenna. Posterior tentorial pits present. Dorsal eye 30 (28–33) in diameter, ventral eye 31 (25–33) in diameter. Reticulation on both surfaces of head.

Antenna 435 (421–451) long, about 0.6× as long as body length; apical segments broader than other segments and 1.5× (1.4–1.6) as long as 3rd segment. Antennal setae predominately of thin, fleshy type; scape and pedicel with hairlike setae; apical segment with 1 or 2 antennal bristles and 1 (1–3) subapical sensory seta. Antennae apparently without placodic or basiconic sensillae.

Front pair of legs shortest, middle pair normally slightly longer than hind pair. Total length of trochanter, femur, tibia, tarsus and claw of each leg as follows: Front 338 (313–368), middle 368 (345–390) and hind 363 (338–375). Each trochanter with 3 pairs of campaniform sensillae. Hind tibia/tarsus 1.1 (1.1–1.2). Tarsi unsegmented, campaniform sensilla near base of tibia, and with pair of capitate digtules which extend to tip of claw. Claws without denticle; digitules of same size and shape as on tarsus. Legs setae hairlike, without tibial spurs.

Prothorax separated from genae by constriction. Pronotal ridge conspicuous, occasionally dorsomedial area lightly sclerotized, nearly touching proepisternum + cervical sclerite laterally; pronotal sclerites lightly sclerotized or absent. Posttergite apparently absent. Proepisternum + cervical sclerite with anterior ridge articulating with postocular ridge; propleural ridge well developed. Prosternum conspicuous, heavily sclerotized medially, less definite laterally.

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Fig. 4. *Grammococcus adetocorymbus*, adult male. A, dorsoventral view; B, *G. corymbus* n. sp., dorsal view of penial sheath; C, ventral view of penial sheath.

Mesothorax with prescutum surrounded by well-developed prescutal ridges, covered by reticulation pattern. Membranous area posterior of prescutum. Small area of scutum adjacent of membranous area reticulated. Scutellum with large internal foramen. Large membranous area between scutellum and postnotum with noticeable reticulation. Mesopleural ridge well developed. Episternum incompletely divided by membranous area, subepisternal ridge weakly sclerotized, not reaching level of membranous area. Lateropleurite well developed, bounded anteriorly by weakly sclerotized extension of marginal ridge of basisternum. Epimeron absent. Basisternum lightly reticulated, divided by well-developed median ridge connecting marginal and precoxal ridges; furca large and well developed.

Metathorax without suspensorial sclerites and postnotum. Episternum and epimeron composed of irregularly sclerotized areas on each side of short pleural ridge; precoxal ridge absent. Metasternal plate composed of weakly sclerotized area.

Wings 337 (325–368) long; hamulohalterae absent; without setae, circular sensoria, or alar lobe.

Abdominal terga inobvious except on segment VIII; sterna irregular, lightly sclerotized on segments II–VI, well developed on segments VII and VIII. Dorsal setae on segment VIII on small protuberance, without glandular pouch.

Genital segment unusually short for asterolecaniid (Giliomee, 1968; Giliomee and Munting, 1968; Borchsenius, 1960; Russell, 1941); length 60 (58–63), width 63 (60–65); length/width 1.0 (0.9–1.0). Basal rod well developed. Ventral margin of capsule with conspicuous ridge, dorsal margin unsclerotized, anus inconspicuous.

Notes.—The above description is based on 29 specimens; of the 29, 7 are in the exuviae of the previous instar. The most conspicuous difference between *G. adetocorymbus* and *G. corymbus* is the shape and chaetotaxy of the genital segment.

Fourth-Instar Males (Pupae)
Fig. 5

Body measurements.—Mounted, 711 (519–793) long, 422 (268–488) wide.

Dorsum.—Longest anal-lobe seta 25 (18–30) long; seta mesad of longest seta 9 (5–15) long; other setae representing transverse rows in submarginal areas of posterior abdominal segments. Dermal nodules near base of wings and on medial areas of thorax and head. Wing buds 339 (317–354) long.

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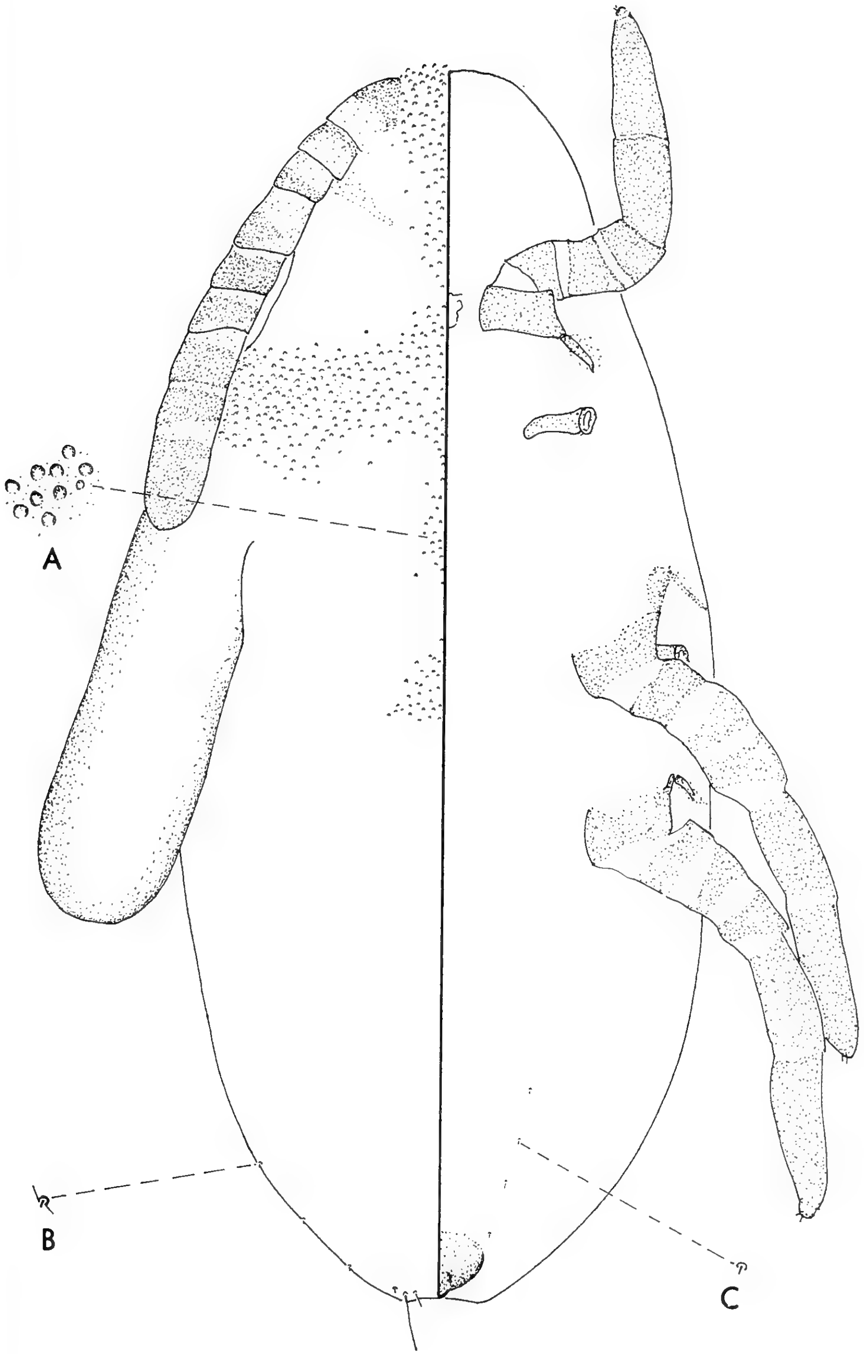
Fig. 5. *Grammococcus adetocorymbus*, pupa. A, dermal nodules; B, marginal seta; C, submedial seta.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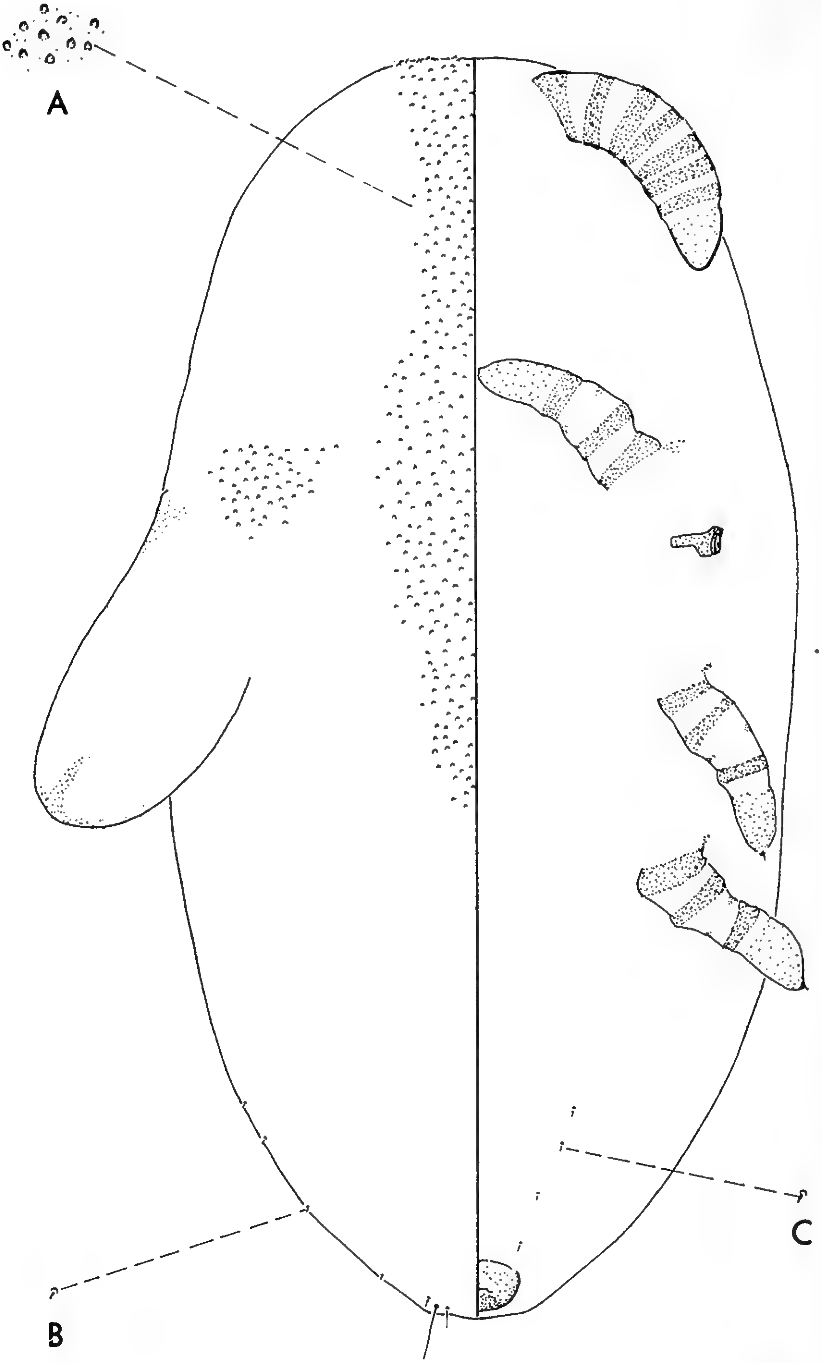
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Venter.—Antennae 333 (252–370) long. Setae forming mediolateral line on posterior 3 or 4 abdominal segments on each side. Spiracles without associated pores. Genital segment lightly sclerotized.

Notes.—The above description is based on 29 specimens.

Third-Instar Males (Prepupae)
Fig. 6

Body measurements.—Mounted, 658 (543–732) long, 372 (244–445) wide.

Dorsum.—Longest anal-lobe seta 24 (23–25) long; seta mesad of longest seta 10 (8–13) long; other setae on submarginal areas of posterior abdominal segments. Dermal nodules near base of wings and on medial areas of thorax and head. Wing buds about 210 long.

Venter.—Antennae 137 (125–145) long. Setae forming mediolateral line on posterior 3 or 4 abdominal segments on each side of body. Spiracles without associated pores or furrows. Genital segment lightly sclerotized.

Notes.—The above description is based on 9 specimens.

Second-Instar Males
Fig. 7

Body measurements.—Mounted 489 (390–689) long, 310 (226–445) wide.

Dorsum.—Longest anal-lobe seta 24 (23–28) long; seta mesad of longest seta 7 (5–9) long; other setae absent. Anal ring composed of 2 lateral, sclerotized pieces connected by posterior and/or anterior bar, each lateral piece with 2 minute setae 2 (1–2) long. Large 8-shaped pores, when present, arranged in 1 pair of longitudinal lines on medial area of dorsum, each line with 12 pores; pores variable as on 2nd-instar female; largest pore on each specimen 13 (11–13) long, 8 (8–9) wide; smallest pore 9 (8–11) long, 7 (6–8) wide. Minute 8-shaped pores scattered over surface, normally absent near body margin and on mesal area; about 2 long. Simple disc pores forming sublateral and submedial longitudinal line on each side of body, submedial line restricted to thorax. Paired, simple disc pores absent. Pore clusters with pores not closely appressed, normally 4 clusters on each side of body, rarely 5, extra clusters each with 1 (1–5) pores; 5 (2–8) quinquelocular pores in each anterior, cephalothoracic cluster; 4 (1–6) in each posterior, cephalothoracic cluster; 5 (1–8) in each anterior, abdominal cluster; and 5 (1–9) in each posterior, abdominal cluster; 20 (6–29) pores on each side of body. Tubular ducts forming 1 pair of submedial and 1 pair

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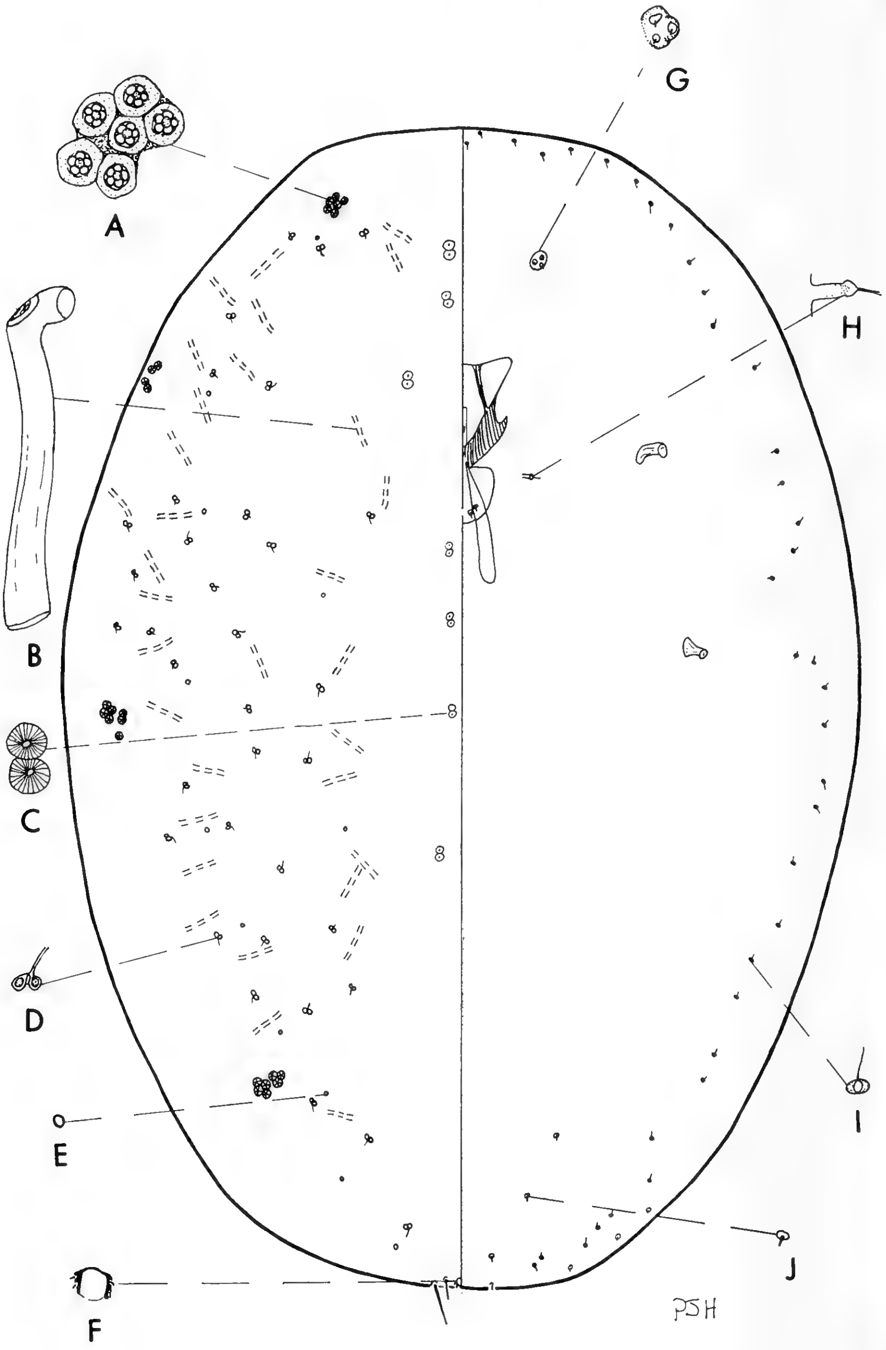
Fig. 6. *Grammococcus adetocorymbus*, prepupa. A, dermal nodules; B, marginal seta; C, submedial seta.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of submarginal, longitudinal lines on each side of body; 29 (25–32) on each side of body; longest duct 28 (25–30) long.

Venter.—Antennae platelike, difficult to measure; each with 3 small setae. Clypeolabral shield 76 (70–80) long, 58 (55–63) wide. Labium nearly rectangular, 36 (33–38) long, 39 (35–43) wide; with 2 pairs of minute setae. Setae forming submedial and marginal longitudinal line on posterior 3 (2–5) segments. Bilocular pores normally lateral of junction of labium and clypeolabral shield; 1 (0–2). Submarginal 8-shaped pores represented by 36 (30–43) on each side of body.

Notes.—The above description is based on 21 specimens. Second-instar males of *G. adetocorymbus* and *G. corymbus* are very similar. *Grammococcus adetocorymbus* has the anal ring relatively well developed with 2 pairs of small setae, has 1 (0–2) bilocular pore and has the pore clusters with the pores loosely arranged. *Grammococcus corymbus* has a poorly developed anal ring which lacks setae, has 5 (3–6) bilocular pores and has the pore clusters with closely appressed pores.

Grammococcus corymbus Miller and Lambdin, new species
Third-instar Female (Adult)
Fig. 8

Type-material.—Holotype adult female on slide with 13 other specimens: Left label, "*Grammococcus corymbus* Miller and Lambdin, Holotype, Paratypes; on *Elaeis quineesis* Jackq. (Palmaceae), Melgar (Cund.), Colombia, 29-III-1972. F. Mosquera coll."; right label gives map of specimens on slide, locates position of holotype and states "*Grammococcus corymbus* Miller and Lambdin. Holotype, Paratypes; 14 adult ♀." There are 146 paratypes mounted on 19 slides with the same data as the holotype. Holotype and several paratypes are deposited in USNM; 1 paratype slide is deposited in each of the following: BM, MNHN, SA, UCD, UT and ZI.

Field features.—Occurring on foliage.

Body measurements.—Holotype mounted, 573 long (paratypes 526 (445–604)), 549 wide (paratypes 479 (305–586)).

Dorsum.—Same as *G. adetocorymbus* except as follows: Longest anal-lobe seta 28 long (paratypes 28 (25–34)); seta mesad of longest seta not touching anal-ring sclerotization, 13 long (paratypes 10 (8–15)). Large 8-shaped pores on 1 of 94 specimens. About 26 simple disc pores on each side of body. Pore clusters compact, without spaces between pores. Num-

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Fig. 7. *Grammococcus adetocorymbus*, second-instar male. A, pore cluster; B, tubular duct; C, large 8-shaped pore; D, minute 8-shaped pore; E, simple disc pore; F, anal ring; G, antenna; H, bilocular pore; I, submarginal 8-shaped pore; J, seta.

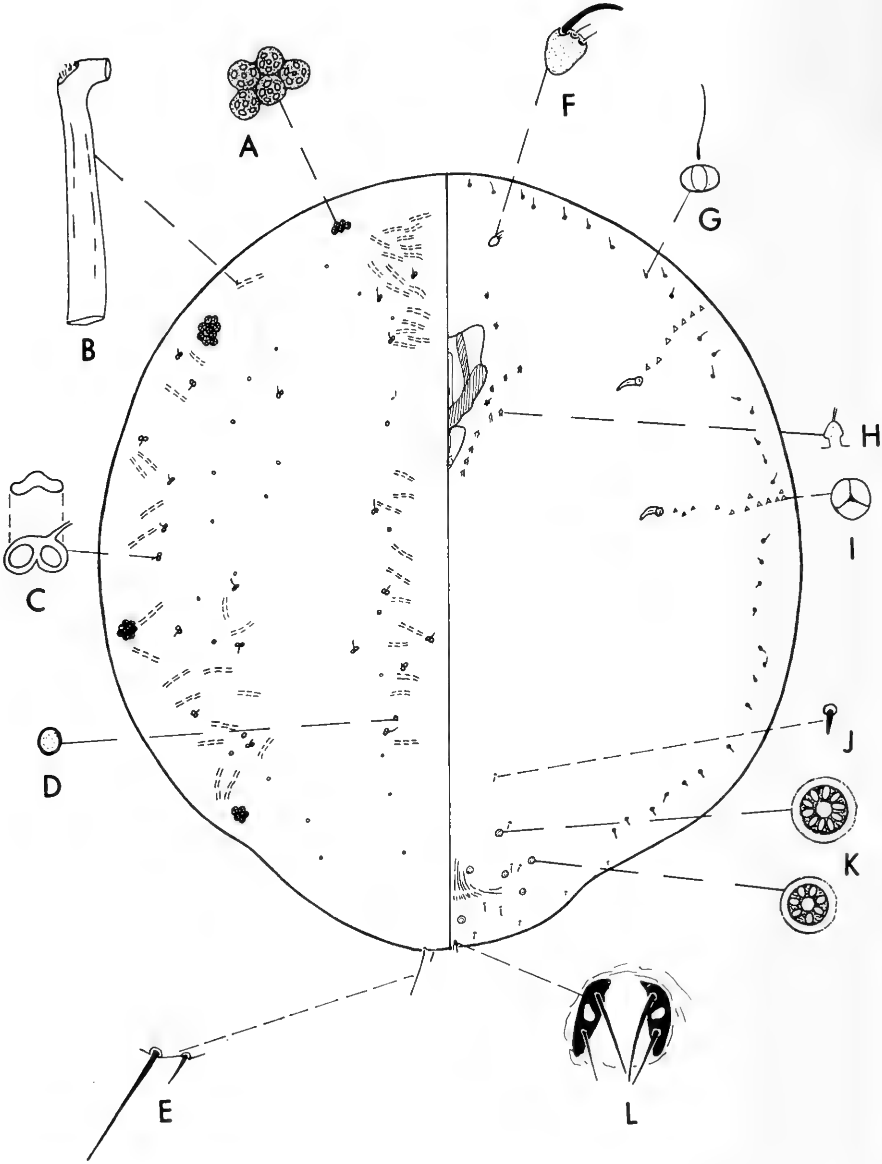


Fig. 8. *Grammococcus corymbus*, adult female. A, pore cluster; B, tubular duct; C, minute 8-shaped pore; D, simple disc pore; E, anal-lobe seta; F, antenna; G, submarginal 8-shaped pore; H, bilocular pore; I, trilocular pore; J, seta; K, multilocular pores; L, anal ring.

ber of quinquelocular pores: 8 and 5 in each anterior, cephalothoracic cluster (paratypes 6 (3–13)); 9 and 5 in each posterior, cephalothoracic cluster (paratypes 6 (3–9)); 8 and 8 in each anterior, abdominal cluster (paratypes 7 (3–12)); and 7 and 5 in each posterior, abdominal cluster (paratypes 6 (3–9)); 32 and 23 quinquelocular pores on each side of body (paratypes 26 (18–47)). Tubular ducts in 2 pairs of longitudinal lines; 44 and 48 on each side of body (paratypes 42 (34–53)); longest duct 35 long (paratypes 34 (30–38)).

Venter.—Antennae 8 long (paratypes 9 (8–13)). Clypeolabral shield 83 long (paratypes 82 (80–88)), 63 wide (paratypes 61 (58–68)). Labium 40 long (paratypes 39 (38–43)), 35 wide (paratypes 39 (33–48)). Posterior spiracular furrows with 11 and 13 trilocular pores (paratypes 12 (10–14)). Bilocular pores represented by 9 and 12 pores on each side of clypeolabral shield (paratypes 11 (9–14)). Submarginal 8-shaped pores represented by 28 and 33 on each side of body (paratypes 31 (24–36)). Multilocular pores on posterior abdominal segments near vulva, 11 pores (paratypes 12 (10–14)). Anal ring in 2 separate pieces, not connected by anterior sclerotized bar, each half with central clear area; 2 pairs of robust setae, posterior pair shortest; longest seta 15 (paratypes 14 (8–20)).

Variation.—The paratypes occasionally have an additional cluster of dorsal quinquelocular pores, the anal-ring setae equal in length, ventral setae on the mediolateral areas of segments 4–9, and the pores in the spiracular furrows with 4 or 5 loculi.

Notes.—The above description is based on 94 specimens. For a comparison of *G. adetocorymbus* and *G. corymbus* see "Notes" of the former species.

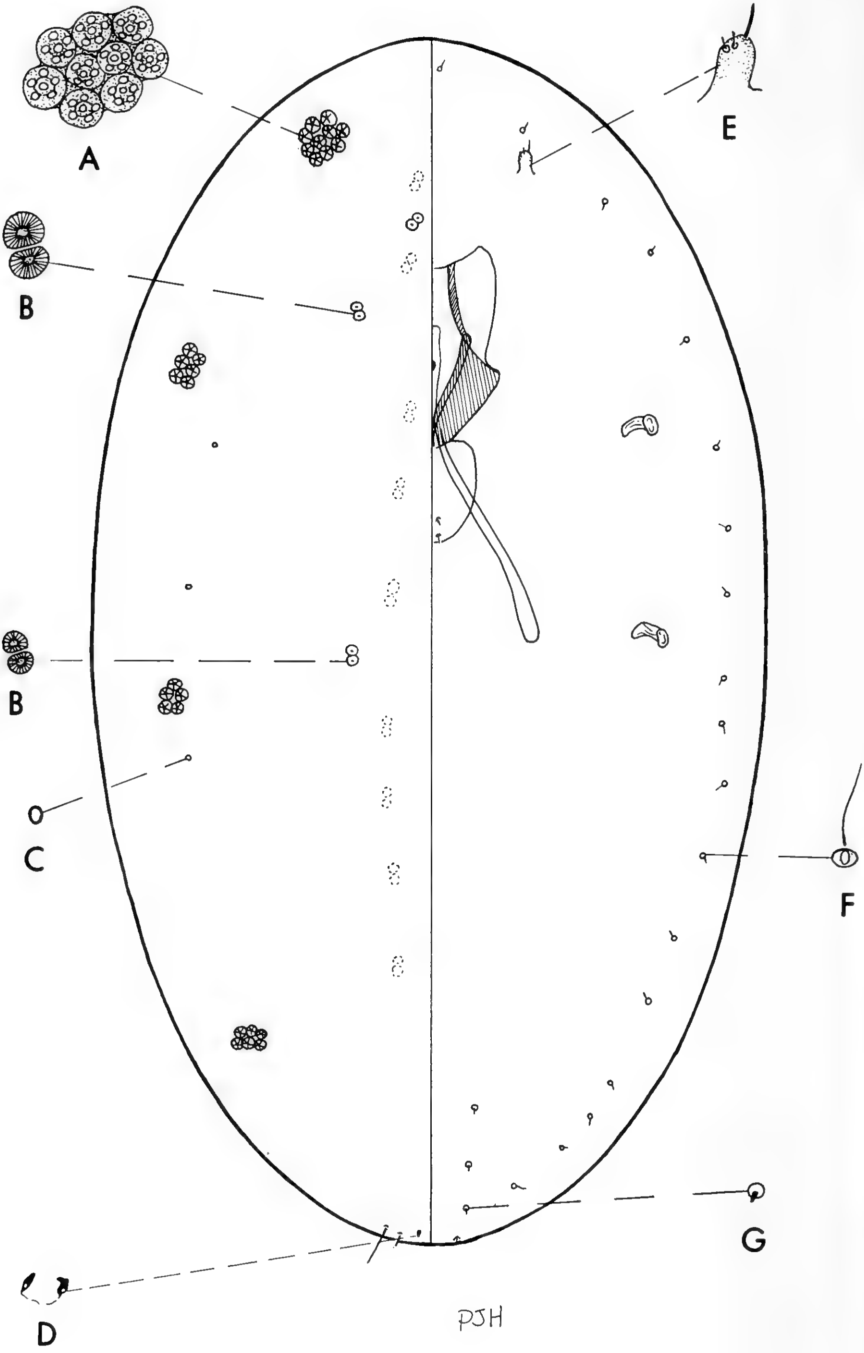
Etymology.—The species epithet is from the Greek *korymbos* meaning "cluster of flowers." The name refers to the clusters of flowerlike pores typical of this taxon.

Second-Instar Females
Fig. 9

Same as *G. adetocorymbus* except as follows:

Body measurements.—Mounted, 435 (323–555) long, 264 (195–348) wide.

Dorsum.—Longest anal-lobe seta about 25 long; seta mesad of longest seta about 6 long. Anal ring composed of 2 lateral, sclerotized pieces without anterior or posterior bars, without setae. Largest 8-shaped pores in medial area about 9 long, 6 wide; smallest about 6 long, 5 wide. Simple disc pores on thorax only, 3 or 4 submedial pores on each side of body. Pore clusters compact: 7 (5–10) quinquelocular pores in each anterior, cephalothoracic cluster; 4 (2–7) pores in each posterior, cephalothoracic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cluster; 6 (5–7) in each anterior, abdominal cluster; and 6 (4–7) in each posterior, abdominal cluster; 23 (18–28) pores on each side of body.

Venter.—Antennae about 8 long. Clypeolabral shield about 64 long, 48 wide. Labium about 34 long, 32 wide. Submarginal 8-shaped pores represented by 20 (16–23) on each side of body. Anal ring without sclerotized bars connecting lateral areas and without setae.

Notes.—The above description is based on 3 poor specimens. For a comparison of 2nd-instar females of *G. adetocorymbus* and *G. corymbus* see "Notes" of the former species.

Fifth-Instar Males (Adults)

Same as *G. adetocorymbus* except as follows:

Body measurements.—Mounted, about 610 long, 262 wide.

Body.—Head without postoccipital ridge; area near base of each antenna with 2 (1–3) head pores: Dorsal eye about 30 in diameter; ventral eye 28 (28–30) in diameter. Antennae about 390 long; apical segment about equal to length of 3rd segment, not noticeably wider than other segments; apical segment with 2 subapical sensory setae. Legs with front pair shortest, hind pair longest. Total lengths of trochanter, femur, tibia, tarsus, claw of each leg as follows: Front 318 (305–330), middle 336 (335–338), hind 340 (338–343). Hind tibia/tarsus length 1.1. Prosternum smaller than on *G. adetocorymbus.* Wings about 350 long. Genital segment 47 (45–50) long, 60 (58–63) wide; length/width about 0.8; setae of penial sheath restricted to posterior half of sheath.

Notes.—The above description is based on 3 specimens. For a comparison of *G. corymbus* with *G. adetocorymbus* see "Notes" of the latter species. Prepupae and pupae of *G. corymbus* are unavailable for comparison.

Second-Instar Males
Fig. 10

Same as *G. adetocorymbus* except as follows:

Body measurements.—Mounted, 445 (420–469) long, 280 (238–323) wide.

Dorsum.—Longest anal-lobe seta 24 (23–25) long; seta mesad of longest seta 4 (3–5). Largest 8-shaped pore on each specimen about 10 long, 6 wide; smallest about 8 long, 5 wide. Minute 8-shaped pores about 3 long. Simple disc pores fewer than on *G. adetocorymbus.* Pore clusters with pores

←

Fig. 9. *Grammococcus corymbus,* second-instar female. A, pore cluster; B, large 8-shaped pore; C, simple disc pore; D, anal ring; E, antenna; F, submarginal 8-shaped pore; G, seta.

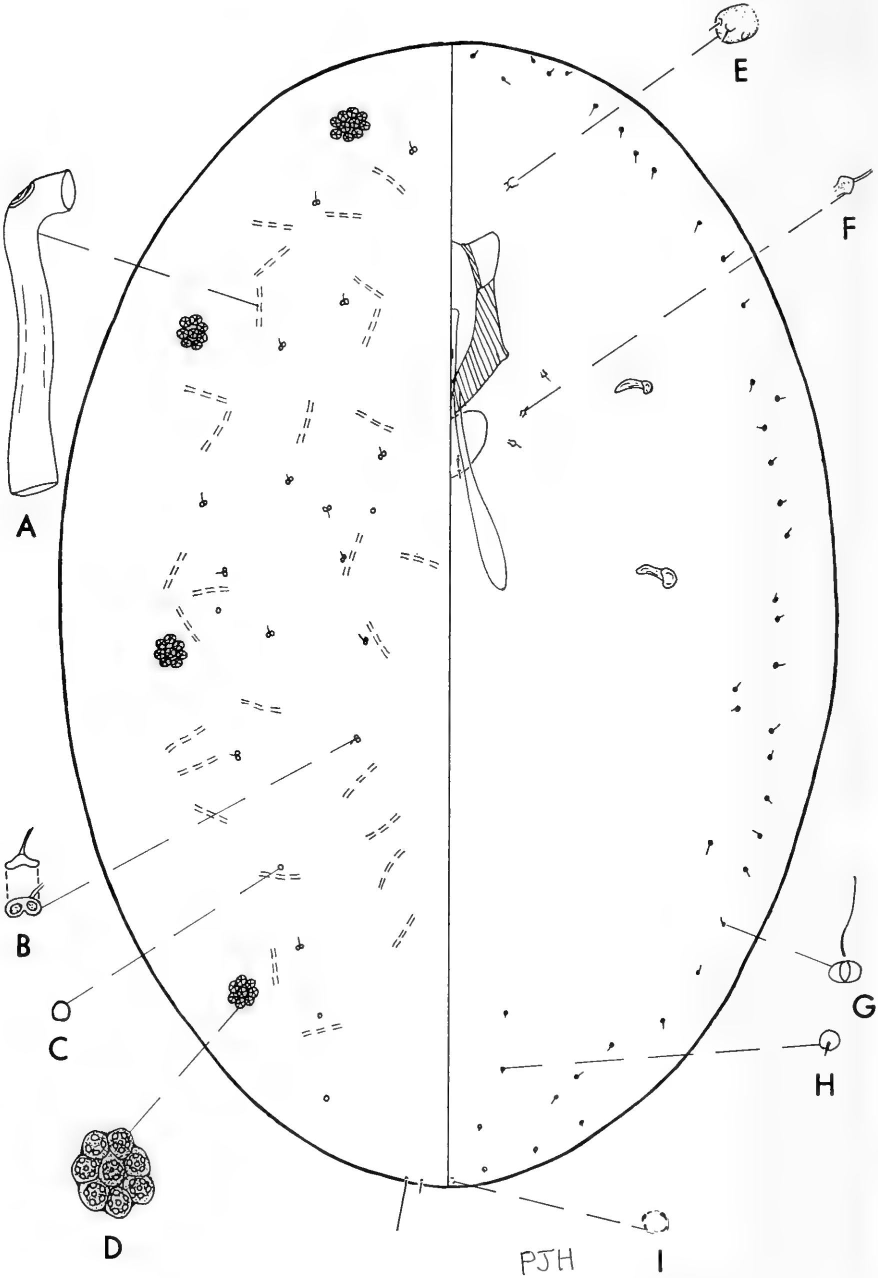

Fig 10. *Grammococcus corymbus*, second-instar male. A, tubular duct; B, minute 8-shaped pore; C, simple disc pore; D, pore cluster; E, antenna; F, bilocular pore; G, submarginal 8-shaped pore; H, seta; I, anal ring.

closely appressed, normally 4 clusters on each side of body, 1 specimen with 1 extra cluster represented by 1 pore; 5 (0–20) quinquelocular pores in each anterior cephalothoracic cluster; 5 (1–8) in posterior cephalothoracic cluster; 6 (1–13) in anterior abdominal clusters; and 4 (1–8) in posterior abdominal clusters; 20 (4–44) pores on each side of body. Tubular ducts 24 (18–27) on each side of body; longest duct about 30 long.

Venter.—Clypeolabral shield 76 (75–78) long, 54 (50–55) wide. Labium 38 (35–40) long, 39 (38–40) wide. Bilocular pores near clypeolabral shield, 5 (3–6) pores. Submarginal 8-shaped pores, 34 (31–38) on each side of body. Anal ring abortive, composed of small, sclerotized spots, without setae.

Notes.—The above description is based on 2 specimens. For a comparison of the 2nd-instar males of *G. corymbus* and *G. adetocorymbus* see "Notes" of the latter species.

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(DRM) Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, Beltsville, Maryland 20705; and (PLL) Agricultural Biology Department, The University of Tennessee, Knoxville, Tennessee 37901.

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LECTOTYPE DESIGNATIONS OF CERTAIN SPECIES OF THRIPS DESCRIBED BY J. D. HOOD AND NOTES ON HIS COLLECTION (THYSANOPTERA)

B. R. Pitkin

Abstract.—Corrections to the published lists of J. D. Hood's papers and list of new names are given. Lectotypes are designated for 100 species described by Hood. Lectotypes designated by other authors for Hood's species are listed. Notes on Hood's collections and published papers are given.

J. Douglas Hood described 1,038 new species and three new varieties of thrips or Thysanoptera. This represents about 20% of the presently estimated 5,000 described species. Hood also erected 138 new genera and subgenera and proposed three new specific names including *Thrips illicii* for *Thrips alysii* Hood. Thirteen of the new species and four of the new genera were described in collaboration with C. B. Williams, (Hood and Williams, 1915; Hood and Williams *in* Hood, 1925 (54)).

Bibliographies of Hood's scientific papers and lists of the new names proposed in them have been published by Bailey (1949) for 1908–1942 and O'Neill (1974) for 1948–1960. No papers by Hood were published between 1943–1947, due no doubt to the second World War. Hood (1948) also published a list of the papers he had had published up to that time.

Both Hood (1948) and O'Neill (1974) numbered Hood's publications and I have used these numbers in parentheses after date of publication throughout this note. Unfortunately Hood 1948 (133) gave the same number, Hood 1909 (4), to two different papers (referred to by Bailey (1949) as Hood 1909a and 1909b) and omitted one paper (referred to by Bailey (1949) as Hood, 1915g). The paper by Hood, 1937 (104), concerns new genera and species from Africa not America (Hood, 1948 (133)). O'Neill (1977) omitted Hood, 1958 (174), from her list of Hood's papers and omitted *Helionothrips compressus* Hood, 1954 (153):192–193, from Formosa from the list of Hood's new names. Unfortunately Hood, 1948 (133), did not publish a list of names, and Bailey (1949) very occasionally cited the date of publication of Hood's papers incorrectly. Thus Hood 1924d was not published until January 1925 (51); Hood 1927i in January 1928 (71); Hood 1929 in January 1930 (73); Hood 1933b in January 1934 (86); Hood 1933e in February 1934 (87); Hood 1938j in January 1939 (121); and Hood 1941b in January 1942 (132). In addition *Cordylothrips peruvianus* was described by Hood in 1937 (110) not in 1927, and *Hyidiothrips atomarius* was described by Hood in 1938 (116) not in 1948. Moreover Bailey misspelled a few specific names (cf. *Ceuthothrips timuqua* Hood, 1938 (116), not 'timupua' or 'timupa'; *Cephalothrips hesperus* Hood, 1941 (131), not 'hexperus'; *Atractothrips bradleyi* Hood, 1938 (113), not 'bardleyi'; *Plesiothrips verticalis* Hood, 1940 (126), not 'veticalis'; and *Adelothrips macrura* Hood, 1941 (131), not 'macura'). In addition Bailey (1949) erroneously included *Exophthalomothrips moultoni* Hood, 1942 (132) (as '1941b'), from Peru in the sub-order Tubulifera.

A relatively small number of the species Hood described were based on unique specimens. Some of these were specifically referred to as holotypes and the others are regarded as such due to their uniqueness. For all but 112 of the remaining species Hood either (a) specifically referred to a holotype specimen in the original description or (b) stated in the introduction to a particular paper that 'the holotypes and allotypes . . . will remain in the collection of the author' (Hood, 1925 (54); Hood, 1927 (66); and Hood, 1927 (71)) or 'holotypes and allotypes will remain in the writers collection' (Hood, 1934 (88)) or 'holotypes, allotypes and a portion of the paratypes are in his (Hood's) collection' (Hood, 1935 (95)) or 'holotypes—and the allotypes in so far as they exist—remain in the authors collection, while a series of paratypes has been returned . . .' Hood, 1937 (104). By these criteria I consider that *Coremothrips pallidus* Hood, 1925 (54); *Frankliniella parvula* Hood, 1925 (54); *Eupathithrips spectator* Hood, 1934 (88); *Macrophthalmothrips helenae* Hood, 1934 (88); *Fauriella natalensis* Hood, 1937 (104); and *Opisthothrips elytropappi* Hood, 1937 (104) already have valid holotype designations (cf. O'Neill, Arnaud and Lee (1971)). Similarly I consider that *Astrothrips angulatus* Hood, 1925 (54) (cf. Wilson (1975)) already has a valid holotype designation.

There are 100 species described by Hood which do not have valid holotype or lectotype designations. For all of these species Hood selected a specimen which he labelled as the holotype. In order to preserve the status that Hood intended these specimens to have, I am designating them here as lectotypes. I have also included those lectotypes designated by other workers in this note.

Hood's thrips collection was accessioned by the U.S. National Museum (USNM) in 1965. At that time it was estimated to comprise 60,000 slide-mounted specimens. These included holotypes or syntypes labelled as holotypes of all of the species and varieties described by Hood except two. One of these, *Chaeturothrips machadoi* Hood, 1954 (154), is in the Dundo Museum, Angola and the other, *Actinothrips monochaetus* Hood, 1935 (97), is in the British Museum (Natural History), London (BMNH). About 1,350 type-specimens of nearly 100 species were accessioned without name and type-status labels. Some of these specimens also lacked data labels. Each series of these unlabelled type-specimens was usually identified as such by an associated paper label written by Hood and bearing the scientific name of the series and sometimes a note on the characteristics of the species. The first slide in each series of unlabelled specimens in all cases except that of *Glyptothrips arkansanus* Hood, 1957 (166), had the word 'HOLOTYPE' written directly on the glass slide in black ink. Where Hood had selected an allotype or 'morphotype,' he labelled those specimens appropriately. None of the specimens, assumed here to be paratypes because of their collection data, were labelled by Hood as paratypes. I have written name and type-status labels and where necessary data labels for all of these unlabelled types. Occasionally Hood changed the spelling slightly in publication from that on the label. A few times he changed the name completely. Notes on these changes are included below. I have written the published name on the slides in the U.S. National Museum. However, it should be stressed that not all of Hood's type-specimens are in the USNM. Hood and the authorities of the U.S. National Museum exchanged a number of specimens with other institutions and individuals and it is likely that these specimens are labelled 'PARATYPE.' I was not able to label paralectotypes in other locations except the BMNH.

In addition to name and type-status labels I have written data labels for the 4,000 or more slides in Hood's collection in the U.S. National Museum that lacked them. These include numerous type-specimens. Each slide I labelled was identifiable by a number engraved on the slide, anterior to the specimen(s). The numbers, referred to as "Hood Nos.," relate to a card index in the USNM. I have quoted these numbers in all cases where possible in the following list.

All names listed below are in their original combinations. For any changes in nomenclature and synonymy see Jacot-Guillarmod's Catalogue of the Thysanoptera of the World (Jacot-Guillarmod, 1970, 1971, 1974, 1975 and in press). The species are arranged alphabetically within genera and the genera are arranged alphabetically within families. The families are arranged systematically from most primitive to most advanced. I have used the terms macropterous (macr.), micropterous (micr.), brachypterous (brach.) and apterous (apt.), in the same sense as Hood, to mean fully winged, short winged, extremely reduced wings and wingless, respectively. The term dealate indicates that the wings are broken off.

Merothripidae

Merothrips brevisetis Hood, 1954 (149):20–21.

Holotype ♀ (macr.).—BRAZIL: Pará, Belém, (Instituto Agronomico do Norte), 2 August 1951 (J. D. Hood). Dead branches of *Hevea*. USNM Type 71522.

Due to a typographical error there is some ambiguity concerning the holotype data. The female specimen collected on 23 July is the apterous 'morphotype.'

Heterothripidae

Aulacothrips dictyotus Hood, 1952 (146):142.

Lectotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, 25 May 1949 (F. Plaumann). Hood No. 2044. USNM Type 74318. Here designated.

This species was originally described from two females, both in the USNM. The paralectotype was collected on 'Compositae: No. 41' 15 January 1949.

Fauriella natalensis Hood, 1937 (104):98–101.

Holotype ♀ (macr.).—SOUTH AFRICA: Natal, Zululand, Nolumu, 22 September 1922 (J. C. Faure). In flowers of tree-like Rhus. Faure's No. T. 50. USNM Type 71232. Designated as a lectotype by O'Neill, Arnaud and Lee, 1971:25.

This species was originally described from 14 females including a '♀ paratype.' However in the introduction to the paper Hood refers to 'holotypes.' There are 3 female paratypes in addition to the holotype in the USNM.

Heterothrips arisaemae Hood, 1908 (1):362–363.

Lectotype ♀ (macr.).—USA: Illinois, Urbana, Augerville Woods, 18 May 1907 (F. Gates). In blossoms of Jack-in-the-pulpit. USNM Type 74289. Here designated.

This species was originally described from 12 females and 2 males. In addition to the lectotype there are 6 female and 2 male paralectotypes in the USNM and all of these have data identical to the lectotype.

Heterothrips sericatus Hood, 1913 (12):66–67.

Lectotype ♀ (macr.).—PUERTO RICO: Rio Piedras, 11 June 1912 (T. H. Jones) [Ex collection H. M. Russell]. "In flowers of guava *(Psidium guajava* L.)." Acc. No. 507, 1912. USNM Type 74304. Here designated.

This species was originally described from 33 females and 4 males including an 'allotype' from Puerto Rico. In addition to the lectotype there are 13 female and 1 male paralectotypes in the USNM.

Opisthothrips elytropappi Hood, 1937 (104):102–105.

Holotype ♀ (macr.).—SOUTH AFRICA: Cape Province, Grahamstown, 21 April 1927 (J. C. Faure). On *Elytropappus rhinicerotis.* Faure No. T48. USNM Type 71233. Designated as a lectotype by O'Neill, Arnaud and Lee, 1971:25.

This species was originally described from 16 females and 5 males including a 'paratype' of each sex. However in the introduction to the paper Hood refers to 'holotypes' of the species described. There are 3 female and 3 male paratypes in addition to the holotype in the USNM.

Aeolothripidae

Aeolothrips vehemens Hood, 1927 (67):123–124.

Lectotype ♀ (macr.).—USA: New Mexico, Chusca Mountains, 1 July 1918 (A. Wetmore). On *Populus aurea.* Hood No. 397. USNM Type 74281. Here designated.

This species was originally described from 2 females, 1 of which Hood referred to as a 'paratype.' This has data identical to the lectotype and is regarded here as a paralectotype.

Stomatothrips flavus Hood, 1912 (7):64–66.

Lectotype ♀ (macr.).—MEXICO: Monterey, 5 July 1908 (C. A. Hart). USNM Type 74266. Here designated.

This species was originally described from 'a good series of both sexes.'

Thripidae

Anaphidothrips brasiliensis Hood, 1954 (151):212.

Lectotype ♀ (macr.).—BRAZIL: Campo Grande, Distrito Federal, 28 June 1948 (J. D. Hood, A. da Costa Lima and A. Silva). On *Andropogon,* probably *condensatus* Kunth. Hood No. 1667. USNM Type 74357. Here designated.

This species was originally described from 3 females. Only the lectotype and 1 female paralectotype are in the USNM, and these have identical data.

Anaphothrips decolor Hood, 1925 (56):101.

Lectotype ♀ (macr.).—USA: Colorado, Golden, (South Table Mountain) 20 June 1918 (L. O. Jackson). Miscellaneous. Hood No. 507. USNM Type 74352. Here designated.

This species was originally described from an unspecified number of females. In addition to the lectotype there is, in the USNM, a single female paralectotype, originally labelled as a paratype, which has data identical to the lectotype.

Arpediothrips mojave Hood, 1927 (69):198.

Lectotype ♀ (? dealate macr.).—USA: California, Mojave, 14 August 1927 (J. D. Hood). At base of leaves of Joshua tree or Tree Yucca (*Yucca brevifolia* Engelm) in the Mojave Desert. Hood No. 804. USNM Type 71234. Designated by O'Neill, Arnaud and Lee (1971:25).

This species was originally described from an unspecified number of specimens of both sexes from the Mojave Desert, California. In addition to the lectotype there are 192 female and 9 male paralectotypes in the USNM and 6 female and 1 male paralectotypes in the BMNH. These are mainly from Mojave, California but also include specimens from Lancaster, Littlerock, Victorville, the San Bernardino Mountains and Blythe, California; Yavapai, Arizona; Deming, New Mexico; and Finlay, Texas collected between 14 August and 4 September 1927 mainly on *Yucca brevifolia* but also on *Y. ?baccata* and *Y. ?elata.*

Astrothrips angulatus Hood, 1925 (54):50–51.

Holotype ♀ (macr.).—BRITISH WEST INDIES: Grenada, 25 March 1915 (C. B. Williams). On leaves of Cacao. Williams No. 599. USNM Type 71516.

This species was originally described from an unspecified number of females from Grenada, Guadeloupe and Trinidad. Hood (1925) however referred to 'holotypes, allotypes and . . . paratypes' of all the species described in that paper. The designation of a lectotype by Wilson (1975:32–33) is therefore considered unnecessary. Wilson listed the type-material (as lectotype and paratypes) and synonymised the species with *Anisopilothrips venustulus* (Priesner).

Bregmatothrips venustus Hood, 1912 (7):67–79.

Lectotype ♀ (brach.).—USA: Texas, Brownsville, (C. A. Hart). USNM Type 74358. Here designated.

This species was originally described from 'several females of both forms.'

Chirothrips cuneiceps Hood, 1940 (126):547–550.

Lectotype ♀ (macr.).—USA: New York, Oswegatchie, 13 August 1939 (J. D. Hood). Sweeping. USNM Type 74365. Here designated.

This species was originally decribed from 10 females and 2 males including 1 female and 1 male paratypes. In addition to the lectotype there are only 6 female and 2 male paralectotypes in the USNM.

Coremothrips pallidus Hood, 1925 (54):52.

Holotype ♀ (macr.).—BRITISH WEST INDIES: Trinidad, Evasdale, near Sangre Grande, 11 October 1916 (C. B. Williams). Cocoa. USNM type 71235.

This species was originally described from an unspecified number of macr. females. Hood, 1925 (54), refers to 'holotypes, allotype and . . . paratypes' in the introduction to this paper. This reference is interpreted here as a holotype designation for this and other species described in that paper. The designation of a lectotype by O'Neill, Arnaud and Lee (1971) is considered here unnecessary.

Enneothrips (Enneothripiella) fuscus Hood, 1954 (151):209–210.

Lectotype ♀ *(macr.)*.—BRAZIL: Pará, Corcovado, (Marajo I., near Breves), 14 August 1951 (J. D. Hood and F. Camargo). Dead branches with leaves. Hood No. 2596. USNM Type 74397. Here designated.

This species was originally described from "several females from dead branches with leaves." In addition to the lectotype there are 5 macr. female paralectotypes in the USNM.

Frankliniella achaeta Hood, 1925 (55):81.

Lectotype ♀ *(macr.)*.—USA: Colorado, 1916 (L. O. Jackson). Sweeping. USNM Type 72600. Here designated.

This species was originally described from an unspecified number of females, including a 'paratype' from Colorado. In addition to the lectotype there are 2 female paralectotypes with data similar to the lectotype.

Frankliniella ameliae Hood, 1925 (55):77.

Lectotype ♀ *(macr.)*.—PANAMÁ: Boguete, 28 February 1914 (J. Zetek). In flower. Hood No. 209. USNM Type 74431. Here designated.

This species was originally described from an unspecified number of females including a 'paratype' from Panamá. In addition to the lectotype, 3 female and 2 male paralectotypes were collected with the lectotype; 4 females were collected at the same locality on 29 February 1914; and 1 female was collected at the same locality on 28 February 1914.

Frankliniella auripes Hood, 1915 (27):18–19.

Lectotype ♀ *(macr.)*.—PERU: Lima, 13 January 1913 (E. W. Rust). From 'Jerusalem cherry.' USNM Type 74423. Here designated.

The species was originally described from 3 females with identical data. Only 2 of these, the lectotype and paralectotype, are in the USNM.

Frankliniella difficilis Hood, 1925 (55):73–74.

Lectotype ♀ *(macr.)*.—FRENCH WEST INDIES: Guadeloupe, 12 March 1915 (C. B. Williams). Flowers of *Hydrangea.* USNM Type 74434. Here designated.

This species was originally described from an unspecified number of specimens of both sexes (including a 'paratype') from 'Guadeloupe and Martinique.' In addition to the lectotype there are 2 female and 7 male paralectotypes from Guadeloupe and 6 female and 1 male paralectotypes from Martinique in the USNM.

Frankliniella extremitata Hood, 1937 (106):111–113.

Lectotype ♀ *(macr.)*.—PERU: Vicinity of Sani Beni, 840 m, 31 August 1955 (F. Woytkowski). In flowers. Hood No. 1124. USNM Type 74435. Here designated.

This species was originally described from 12 females including a 'paratype.' In addition to the lectotype there are 8 female paralectotypes with data identical to the lectotype.

Frankliniella fuscicauda Hood, 1927 (69):197.

Lectotype ♀ *(macr.).*—USA: Arizona, Congress Junction, 22 August 1927 (J. D. Hood). Flowers of *Baileya multiradiata.* Hood No. 836. USNM Type 74420. Here designated.

This species was originally described from an unspecified number of females. In addition to the lectotype female there are 47 females and 7 males in the USNM, 1 female and 3 males in the BMNH and 1 female and 1 male in the Senckenberg Museum, Frankfurt with the same data as the lectotype and a further 5 females and 1 male from Arizona, Aguila, 21 August 1927 (J. D. Hood), on flowers of *Baileya multiradiata*, Hood No. 847. All of these are labelled 'PARATYPE' and are regarded here as paralectotypes.

Frankliniella parvula Hood, 1925 (54):49.

Holotype ♀ *(macr.).*—BRITISH WEST INDIES: Trinidad, Mareval Valley, 27 March 1915 (C. B. Williams). Flowers of rose. USNM Type 71236.

This species was originally described from an unspecified number of males and females. However Hood, 1925 (54), refers to 'holotypes, allotypes and . . . paratypes' in the introduction to this paper. This reference is interpreted here as a holotype designation for this and other species described in that paper. The designation of a lectotype by O'Neill, Arnaud and Lee (1971) is considered here unnecessary.

Helionothrips stephaniae Hood, 1937 (104):108–110.

Holotype ♀ *(macr.).*—SOUTH AFRICA: Transvaal, Woodbush, Pietersburg, 12 April 1924 (J. C. Faure). On *Stephania meyeriana* Haw. Hood No. 500. USNM Type 71517. Designated as a lectotype by Wilson (1975:142).

This species was originally described for 11 females including a 'paratype.' In the introduction to the paper Hood refers to 'holotypes' of the species described.

Heliothrips phaseoli Hood, 1912 (9):113–114.

Lectotype ♀ *(macr.).*—USA: Texas, Brownsville, 26 June 1908 (C. A. Hart). On bean plants. USNM Type 74325. Here designated.

This species was originally described from 'many specimens of both sexes' from Brownsville, Texas and Matamoras, Mexico.

Physothrips ventralis Hood, 1918 (42):116.

Lectotype ♀ *(macr.).*—CAMEROON: 23 November 1915 (A. W. Jobbins-

Pomeroy). Flowers of monkshood. Hood No. 160. USNM Type 74530. Here designated.

This species was originally described from 'numerous specimens of both sexes from a large variety of flowers' in Cameroon and southern Nigeria. In addition to the lectotype there are 70 female and 6 male paralectotypes from Cameroon and 24 female paralectotypes from southern Nigeria in the USNM, and 1 female paralectotype from Nigeria in the BMNH.

Plesiopsothrips trinidadensis Hood, 1956 (164):64–66.

Holotype ♀ (macr.).—BRITISH WEST INDIES: Trinidad, El Tucuche, 22 June 1951 (J. D. Hood). Dead branches. Hood No. 2529. USNM Type 74221.

The unique female holotype was labelled by Hood as 'trinitatis.' There is no doubt that this specimen is the holotype of *Plesiopsothrips trinidadensis* Hood.

Pseudodendrothrips alboniger Hood, 1952 (146):145.

Lectotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, 26 November 1949 (F. Plaumann). On *Terminalia.* Plaumann No. 183. USNM Type 74449. Here designated.

This species was originally described from 17 females and 6 males from *Terminalia* and unidentified plants. In addition to the lectotype there are 11 female and 5 male paralectotypes in the USNM and 1 female paralectotype in the BMNH and all of these are from Nova Teutonia.

Psilothrips pardolatus Hood, 1927 (69):198.

Lectotype ♀ (macr.).—USA: California, Thermal (elevation, 100 ft) 18 August 1927 (J. D. Hood). Shaken from *Atriplex polycarpa* Watson. Hood No. 832. USNM Type 71237. Designated by O'Neill, Arnaud and Lee (1971:25).

This species was originally described from an unspecified number of specimens of both sexes from California, Arizona and Texas from undetermined plants. In addition to the lectotype 3 female and 2 male paralectotypes were collected with the lectotype at Thermal, California, 6 female and 1 male paralectotypes from Palm Canyon, California also on *A. polycarpa*, 13 female paralectotypes from Ysleta, Texas on *A. canescens* (Pursh) Nutt., and 8 female paralectotypes from Quijotoa, Arizona on *A. canescens*. All, except 1 female from Palm Canyon which is in the BMNH, are in the USNM.

Sericothrips occipitalis Hood, 1917 (40):32–34.

Lectotype ♀ (macr.).—NIGERIA: Ibadan, 14 January 1915 (A. W. Jobbins-Pomeroy). On *Desmodium lasiocarpum.* Hood No. 50. USNM Type 74491. Here designated.

This species was originally described from 3 specimens including a 'paratype' female and an 'allotype' male. The paralectotype female was collected on *Bougainvillaea glabra* Choisy and the male on *Andropogon tectorum* Schum. and Thonn.

Sericothrips opuntiae Hood, 1936 (100):88–91.

Lectotype ♀ (macr.).—USA: Arizona, Comobabi, 28 August 1927 (J. D. Hood). On *Opuntia* sp. Hood No. 852. USNM Type 74522. Here designated.

This species was originally described from 12 females and 6 males including a 'paratype' female. In addition to the lectotype there are 7 female and 5 male paralectotypes in the USNM and 1 female paralectotype in the BMNH.

Sericothrips pulchellus Hood, 1908 (1):363–364.

Lectotype ♀ (macr.).—USA: Illinois, Muncie, 16 June 1908 (J. D. Hood). On leaves of *Ptelea trifoliata* L. USNM Type 74493. Here designated.

This species was originally described from an unspecified number of specimens of both sexes. In addition to the lectotype there are 7 female and 3 male paralectotypes in the USNM and 3 female paralectotypes in the BMNH, and these have data identical to the lectotype.

Sericothrips tiliae Hood, 1931 (78):151–152.

Lectotype ♀ (macr.).—USA: New York, Morton, 1 September 1930 (J. D. Hood and H. M. Hincher). USNM Type 74517. Here designated.

This species was originally described from 'a large number of specimens' of both sexes from New York.

Taeniothrips aethiops Hood, 1925 (57):2–3.

Holotype ♀ (macr.).—CAMEROON: [Kamerun]; 12 February 1916 (A. W. Jobbins-Pomeroy). Flowers of small shrub. Hood No. 176. USNM Type 74529.

The type-series in the USNM is labelled 'Physothrips aethiops sp. nov.'

Taeniothrips debilis Hood, 1925 (57):5–6.

Holotype ♀ (macr.).—NIGERIA: Ibadan, 14 January 1915, (A. W. Jobbins-Pomeroy). In flowers of *Melia azederach*. Hood No. 53. USNM Type 75107.

The type-series in the USNM is labelled 'Physothrips debilis sp. nov.'

Taeniothrips dilutus Hood, 1925 (57):8–9.

Holotype ♀ (macr.).—EAST AFRICA: Rifigi River, 27 July 1917 (A. W. Jobbins-Pomeroy). Flowers of false ebony. Hood No. 188. USNM Type 74527.

The holotype female is labelled 'Physothrips dilutus sp. nov.'

Taeniothrips modestus Hood, 1925 (57):3–5.

Holotype ♀ (macr.).—CAMEROON: [Kamerun]; 16 February 1916 (A. W. Jobbins-Pomeroy). Flowers of a large bush. Hood No. 177. USNM Type 74534.

The type-series in the USNM is labelled 'Physothrips modestus sp. nov.'

Taeniothrips silvestris Hood, 1935 (92):83–84.

Lectotype ♀ (macr.).—PANAMÁ: Panama Canal, Barro Colorado Island, Gatun Lake, October 1933 (S. Aviles). On *Dichorisandra hexandra.* Hood No. 1078. USNM Type 74525. Here designated.

This species was originally described from 27 females and 5 males including a 'paratype' female and an 'allotype' male. In addition to the lectotype there are 20 female and 4 male paralectotypes in the USNM, and 1 male paralectotype in the BMNH.

Uzelothripidae

Uzelothrips scabrosus Hood, 1952 (146):143–144.

Lectotype ♀ (macr.).—BRAZIL: Pará, Belém, (Instituto Agronomico do Norte), 21 August 1951 (J. D. Hood). Dead dry branches of *Hevea* sp. on ground. Hood No. 2721. USNM Type 74558. Here designated.

This species was originally described from 'many specimens' of both sexes. In addition to the lectotype there are 2 macr. female, 24 apt. female and 1 apt. male paralectotypes, all from the type-locality and in the USNM, and 2 apt. females in the BMNH. There are also 28 apt. females labelled 'TOPOTYPIC' in the USNM.

Phlaeothripidae

Actinothrips trichaetus Hood, 1935 (97):248–252.

Lectotype ♀ (macr.).—PANAMÁ: Canal Zone, Barro Colorado Island, 1933 (J. D. Hood). USNM Type 74969. Here designated.

This species was originally described from 46 macr. females, 41 macr. males and 20 larvae (including a 'paratype' of each sex) from Panamá and Ecuador.

Adelothrips eucharis Hood, 1955 (163):84–88.

Holotype ♀ (macr.).—BRAZIL: Pará, Fordlandia, 10 July 1951 (J. D. Hood). Dead grass. Hood No. 2581. USNM Type 74626.

This species was originally described from 1 macr. female and 1 macr. male including a holotype female and an allotype male. There are 2 slides labelled as 'Adelothrips excellens' by Hood with data identical to that published for *eucharis.* Miss Kellie O'Neill identified these as *eucharis*, and I have labelled them as types of that species.

Adraneothrips huachucae Hood, 1927 (69):202–203.

Lectotype ♀ *(macr.).*—USA: Arizona, Ramsey Canyon (Huachuca Mountains, 30 mi east of Nogales), 2 September 1927 (J. D. Hood). Beating dead oak leaves. Hood No. 927. USNM Type 74587. Here designated.

This species was originally described from an unspecified number of specimens of both sexes. In addition to the lectotype there are 14 female and 11 male paralectotypes in the USNM, and 2 female and 1 male paralectotypes in the BMNH.

Allothrips megacephalus Hood, 1908 (1):373.

Lectotype ♀ *(apt.).*—USA: Illinois, Urbana, Augerville Woods, 9 November 1907 (J. D. Hood). Under bark on living osage-orange tree. USNM Type 74970. Here designated.

This species was originally described from 'several females, one of them brachypterous.' In addition to the apt. lectotype there are 4 apt. female and 1 brach. female paralectotypes in the USNM.

Bagnalliella arizonae Hood, 1927 (69):201.

Lectotype ♀ *(brach.).*—USA: Arizona, Fort Huachuca, September 1927 (J. D. Hood). At base of leaves of *Yucca elata* Engelm. Hood No. 855. USNM Type 74626. Here designated.

This species was originally described from an unspecified number of specimens of both sexes from Arizona, New Mexico and Texas. In addition to the lectotype there are 24 macr. female, 111 brach. female and 6 brach. male paralectotypes in the USNM and 1 brach. female and 1 brach. male paralectotypes in the BMNH.

Bagnalliella desertae Hood, 1927 (69):201.

Lectotype ♀ *(macr.).*—USA: California, Victorville, 15 August 1927 (J. D. Hood). At base of leaves of *Yucca baccata* Torr. in Mojave Desert. Hood No. 809. USNM Type 74629. Here designated.

This species was originally described from an unspecified number of specimens of both sexes. In addition to the lectotype there are 1 macr. female, 52 brach. female and 16 brach. male paralectotypes in the USNM and 2 brach. female and 1 brach. male paralectotypes in the BMNH. All of the type-series are labelled 'deserti.'

Bagnalliella huachucae Hood, 1927 (69):200.

Lectotype ♀ *(macr.).*—USA: Arizona, Ramsey Canyon, (Huachuca Mountains, 30 mi east of Nogales), 2 September 1927 (J. D. Hood). On *Yucca* sp. (perhaps *Y. buccata* Torr.), at base of leaves. Hood No. 928. USNM Type 74631. Here designated.

This species was originally described from an unspecified number of specimens. In addition to the lectotype there are 7 macr. female, 5 brach. female and 7 brach. male paralectotypes all bearing the same data as the lectotype.

Bagnalliella mojave Hood, 1927 (69):200–201.

Lectotype ♀ (macr.).—USA: California, Mojave, in the Mojave Desert. 14 August 1927 (J. D. Hood). At base of leaves of Joshua tree or Tree Yucca (*Yucca brevifolia* Engelm.). Hood No. 804. USNM Type 74630. Here designated.

This species was originally described from an unspecified number of specimens of both sexes. In addition to the lectotype there are 1 macr. female, 85 brach. female and 8 brach. male paralectotypes from Mojave, 19 brach. female paralectotypes from Victorville, and 47 brach. female paralectotypes from Lancaster, California. All of these, except 3 brach. females and 1 brach. male from Mojave and which are in the BMNH, are in the USNM.

Chthonothrips nigrocinctus Hood, 1957 (170):143.

Holotype ♀ (apt.).—BRAZIL: Santa Catarina, Nova Teutonia, September 1955 (F. Plaumann). Under fallen leaves. Hood No. 1787. USNM Type 74184.

The last 6 lines of the original description of this species have been transposed with the first 5 lines of the original description of *Chortothrips* gen. nov., Hood, 1957 (170): 143 (O'Neill, 1974). Contrary to O'Neill (1971), therefore, Hood designated a holotype for *nigrocinctus*.

Cordylothrips peruvianus Hood, 1937 (110):518–519.

Lectotype ♀ (macr.).—PERU: Almirante, Departamento de Amazonas, (elevation about 1,900 m), 20 December 1936 (F. Woytkowski). Dead branches in jungle. Hood No. 1143. USNM Type 75002. Here designated.

This species was originally described from 5 females including a 'paratype.' In addition to the lectotype there are 3 macr. female paralectotypes in the USNM.

Cryptothrips junctus Hood, 1912 (8):139–142.

Lectotype ♀ (brach.).—USA: Michigan, Baldwin. USNM Type 74574. Here designated.

This species was originally described from 18 brach. females, 2 macr. females and 11 brach. males from Michigan and Illinois.

Cryptothrips rectangularis Hood, 1908 (2):307–309.

Lectotype ♀ *(apt.)*.—USA: Illinois, Urbana, (near University Forest), 12 May 1908 (J. D. Hood). Under dead bark on peach tree. USNM Type 75001. Here designated.

This species was originally described from 'four winged individuals.' These are all in the USNM.

Cryptothrips sordidatus Hood, 1927 (69):199.

Lectotype ♀ *(macr.)*.—USA: California, Palo Alto, 4 August 1927 (J. D. Hood). Beating dead branches of *Salix* sp. Hood No. 744. USNM Type 75006. Here designated.

This species was originally described from an unspecified number of specimens of both sexes. In addition to the lectotype, there are 1 brach. female and 4 brach. male paralectotypes, all with data identical to the lectotype, in the USNM.

Cyphothrips dorsalis Hood, 1952 (146):172–173.

Lectotype ♀ *(macr.)*.—BRAZIL: Pará, Belém, (Instituto Agronomico do Norte), 17 August 1951 (J. D. Hood). Dead leaves of *Euterpe oleraceae*. Hood No. 2711. USNM Type 74822. Here designated.

This species was originally described from 5 females and 2 males from the same locality. In addition to the lectotype there are 2 macr. female and 2 macr. male paralectotypes in the USNM.

Diceratothrips cubensis Hood, 1941 (131):178–180.

Lectotype ♀ *(macr.)*.—CUBA: Maranzas, San Miguel de los Banos, 18 July 1940 (J. C. Bradley). Dead branches. USNM Type 75013. Here designated.

This species was originally described from 2 females including a 'paratype.' Both specimens are in the USNM.

Diceratothrips setigenus Hood, 1941 (131):176–178.

Lectotype ♀ *(macr.)*.—USA: Texas, Brownsville, 2 March 1939 (J. D. Hood). Dead branches. USNM Type 75023. Here designated.

This species was originally described from 4 females, including a 'paratype.' In addition to the lectotype there are 2 female paralectotypes in the USNM.

Diopsothrips brunneus Hood, 1934 (87):424–425.

Lectotype ♀ *(macr.)*.—PANAMÁ: Canal Zone, Barro Colorado Island, 1933 (J. D. Hood and S. Aviles). Dead branches. USNM Type 75026. Here designated.

This species was originally described from 6 macr. females from Panamá.

Diopsothrips flavus Hood, 1934 (87):423–424.

Lectotype ♀ (macr.).—PANAMÁ: Canal Zone, Barro Colorado Island, 1933 (J. D. Hood). USNM Type 75025. Here designated.

This species was originally described from 27 macr. females and 13 macr. males from Panamá.

Eupathithrips spectator Hood, 1934 (88):73–76.

Holotype ♀ (macr.).—PANAMÁ: Panama Canal, Barro Colorado Island, Gatun Lake, 25 June 1933 (J. D. Hood). On ripe fruit of Corozo Palm. Hood No. 947. USNM Type 71238.

This species was originally described from 22 females, 30 males and 3 nymphs taken on 'Barro Colorado Island, Canal Zone (type-locality) and at Porto Bello, Panamá.' This reference and the references to 'holotypes,' 'allotypes' and 'paratypes' in the introduction of this paper are interpreted here as a holotype designation. The designation of a lectotype by O'Neill, Arnaud and Lee (1971) is here considered unnecessary.

Eurythrips citricollis Hood, 1941 (131):240–243.

Lectotype ♀ (macr.).—USA: Florida, Winter Park, 11 March 1941 (M. J. Westfall, Jr.). Fallen pine needles. USNM Type 74662. Here designated.

This species was originally described from 3 macr. and 11 brach. females including a macr. 'paratype' and a brach. 'paratype.' In addition to the lectotype there are 2 macr. female and 9 brach. female paralectotypes in the USNM and 1 macr. female paralectotype in the BMNH.

Eurythrips nigricornis Hood, 1960 (175):61–63.

Holotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, June 1957 (F. Plaumann). Dead grasses. Hood No. 2944. USNM Type 72626.

This species was originally described from 2 macr. females (including the holotype), 19 brach. females and 6 brach. males from dead grasses. There was an unlabelled series in the USNM, the first specimen of which was labelled 'Eury. sculpturus' and 'HOLOTYPE [1].' These were identified by Mound (1976:56) as *nigricornis* Hood, there is little doubt that they represent the type-series of that species, and I have labelled them as such. A brach. paratype of each sex has been deposited in the BMNH.

Eurythrips umbrisetis Hood, 1934 (87):415–416.

Lectotype ♀ (brach.).—PANAMÁ: Canal Zone, Frijoles, 18 July 1933 (H. H. Hood and J. J. Hook). Dead leaves of *Panicum maximum.* Hood No. 1001. USNM Type 74664. Designated by Mound (1976).

This species was originally described from 2 brach. females from Frijoles, Canal Zone.

Gastrothrips callipus Hood, 1935 (94):182–186.

Lectotype ♀ *(macr.)*.—USA: Texas, Victoria, 1 April 1908 (J. D. Mitchell). On *Chenopodium*. USNM Type 72001. Here designated.

This species was originally described from 3 females and 1 male including a female 'paratype' and male 'allotype.' In addition to the lectotype there is only the single male paralectotype in the USNM.

Gastrothrips firmus Hood, 1952 (146):162.

Lectotype ♀ *(macr.)*.—BRAZIL: São Paulo, Itanhaém, 17 June 1948 (J. D. Hood and J. Lane). Dead branches. Hood No. 1640. USNM Type 71995. Here designated.

This species was originally described from 3 females and 2 males. In addition to the lectotype there are 1 female and 2 male paralectotypes in the USNM.

Gastrothrips picticornis Hood, 1936 (102):272–275.

Lectotype ♀ *(brach.)*.—BRAZIL: Rio de Janeiro, (Angra dos Reis), 10 August 1934 (D. Mendes). Dead twigs of *Anona squamosa*. Hood No. 1208. USNM Type 72004. Here designated.

This species was originally described from 9 brach. females and 2 brach. males including a 'paratype' of each sex. In addition to the lectotype there are 7 brach. female and 2 brach. male paralectotypes in the USNM.

Gastrothrips proteus Hood, 1934 (87):417–419.

Lectotype ♀ *(macr.)*.—PANAMÁ: Canal Zone, Barro Colorado Island, 1933 (S. J. Hook, H. H. Hood and J. D. Hood). Dead leaves and branches. USNM Type 71996. Here designated.

This species was originally described from 1 macr. female, 17 apt. females and 7 apt. males from Panamá.

Gastrothrips ruficauda Hood, 1912 (10):156–157.

Lectotype ♀ *(brach.)*.—USA: Illinois, Grand Tower/Pulaski, October/July ?1909 (C. A. Hart and L. M. Smith). On branches of grape/sycamore/overcup oak *(Quercus lyrata* Walt.). USNM Type 71997. Here designated.

This species was originally described from 3 females.

Glyptothrips arkansanus Hood, 1957 (166):59–60.

Lectotype ♀ *(macr.)*.—USA: Arkansas, Fayetteville, 16 March 1957 (W. H. Whitcomb). On *Andropogon virginicus* L. Hood No. 2764. USNM Type 71993. Designated by Mound and O'Neill (1977).

This species was originally described from '29 females (including holotype).' Mound and O'Neill (1977) were unable to find the type-series in the systematic collections of the USNM. "However specimens in four series of unlabelled slides in the numerical collection were identified as *arkansanus* from the description" (Mound and O'Neill, 1977). Although the data for these specimens contrasted with the published data "There can be little doubt that the specimens . . . comprise the type-series of *G. arkansanus*" (Mound and O'Neill, 1977). Mound & O'Neill (1977) designated "the female at the head of series 2764" as the lectotype.

Glyptothrips flavescens Hood, 1912 (9):116–117.

Lectotype ♀ (macr.).—USA: Illinois, Grand Tower, 1909 (C. A. Hunt). USNM Type 74679. Here designated.

This species was originally described from 3 macr. females. Two of these are from the 'Type-locality,' Grand Tower, and the other is from Pulaski, Illinois.

Haplothrips graminis Hood, 1912 (7):69–70.

Lectotype ♀ (macr.).—USA: Texas, Brownsville (C. A. Hart). USNM Type 74687. Here designated.

This species was originally described from 'a good series of both sexes.'

Haplothrips (*Anchylothrips*) *preeri* Hood, 1939 (125):565–568.

Lectotype ♀ (macr.).—USA: Texas, Palacios, 31 March 1939 (J. D. Hood). On *Spartina alterniflora* var. *glabra* (Muhl.) Fern. USNM Type 74701. Here designated.

This species was originally described from 10 females and 9 males including a 'paratype' of each sex, all from *Spartina alterniflora* at Palacios. In addition to the lectotype there are 7 female and 6 male paralectotypes in the USNM and 1 female and 1 male paralectotypes in the BMNH. One of the females in the USNM has reduced wings.

Holothrips amplus Hood, 1952 (146):160.

Lectotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, 31 December 1948 (F. Plaumann). Dry branches. Hood No. 2018-O. USNM Type 74747. Here designated.

This species was originally described from 3 females. There is only 1 female paralectotype, in addition to the lectotype, in the USNM.

Hoplandrothrips angustatus Hood, 1927 (69):199.

Lectotype ♀ (macr.).—USA: Arizona, Nogales. 30 August 1927 (J. D. Hood). Mesquite-like trees, *Acacia* or *Prosopis.* Hood No. 909. USNM 74767. Here designated.

This species was originally described from an unspecified number of macr. females and brach. males from dead branches of mesquite at Nogales, Arizona. In addition to the lectotype there are 3 macr. female and 3 brach. male paralectotypes in the USNM.

Hoplandrothrips longirostris Hood, 1954 (149):46.

Holotype ♀*(macr.)*.—BRAZIL: Rio de Janeiro, Petrópolis, 27 June 1948 (J. D. Hood). Dead and dying branches of various trees. Hood No. 1672. USNM Type 75090.

This species was originally described from 13 macr. females. None of the 11 females in the USNM were labelled as *Hoplandrothrips longirostris* Hood. The holotype was labelled in ink on the glass slide 'Hoplandrothrips penetralis.' The data for these specimens correspond to the published data of *longirostris*. There is no doubt that the specimens are part of the type-series of this species, and consequently I have labelled them as such.

Hoplandrothrips nigricestus Hood, 1934 (87):429–430.

Lectotype ♀ *(macr.)*.—PANAMÁ: Canal Zone, Barro Colorado Island, 1933 (J. D. Hood). Dead leaves. USNM Type 74766. Here designated.

This species was originally described from 16 macr. females and 7 macr. males from Panamá.

Hoplandrothrips symmetricus Hood, 1942 (132):557–559.

Holotype ♀ *(macr.)*.—PERU: Piedras Grandes, Dept. Huanuco (Andes elevation about 3,000 m), 6 November 1937 (F. Woytkowski). Flowers of a wild potato. Hood No. 1468. USNM Type 74756.

This species was described from an unspecified number of macr. females including a holotype. The type-data were omitted from the original description, and there is only the unique holotype in the USNM.

Idolothrips armatus Hood, 1908 (3):285–287.

Lectotype ♀ *(macr.)*.—USA: Illinois, Carbondale, 20 June 1907 (J. D. Hood). Taken in old dried up *Solidago* galls. USNM 75030. Here designated.

This species was originally described from 8 macr. females and 8 macr. males mainly from galls on *Solidago* at Carbondale, Illinois. In addition to the lectotype there are 4 female and 6 male paralectotypes in the USNM and 1 female paralectotype in the BMNH.

Idolothrips flavipes Hood, 1908 (1):377.

Lectotype ♀ *(brach.)*.—USA: Illinois, Dubois, 28 April, 1908 (C. A. Hart and L. M. Smith). Sifted from dead oak. USNM Type 75034. Here designated.

This species was originally described from 'several males and females, all from Illinois.' In addition to the lectotype there are 8 brach. female and 4 brach. male paralectotypes in the USNM.

Idolothrips tuberculatus Hood, 1908 (3):287–289.

Lectotype ♀ *(macr.)*.—USA: Illinois, White Heath, 26 August 1908 (C. A. Hart). Jarred from branch of white oak (*Quercus alba*). USNM Type 75043. Here designated.

This species was originally described from 4 females and 1 male from white oak at White Heath and Dusky Dell, Illinois. In addition to the lectotype there are 1 macr. female and 1 macr. male paralectotypes in the USNM and 1 macr. female paralectotype in the BMNH.

Lathrobiothrips ramuli Hood, 1934 (87):421–422.

Lectotype ♀ *(macr.)*.—PANAMÁ: Canal Zone, Barro Colorado Island, 30 July 1933 (J. D. Hood). USNM Type 74825. Here designated.

This species was originally described from 11 macr. females and 4 macr. males from Panamá.

Leptothrips heliomanes Hood, 1927 (69):202.

Lectotype ♀ *(macr.)*.—USA: California, Palm Canyon (near Palm Springs, elevation 100 ft), 17 August 1927 (J. D. Hood). Shaken from *Atriplex polycarpa* Watson. Hood No. 830. USNM Type 74723. Here designated.

This species was originally described from an unspecified number of females and males from Palm Canyon, California on an undetermined plant. In addition to the lectotype there are 5 female and 2 macr. male paralectotypes in the USNM.

Liothrips avocadis Hood, 1935 (92):97–99.

Lectotype ♀ *(macr.)*.—PANAMÁ: Canal Zone, Ancon, 24 August 1933 (J. Zetek). Avocado. Hood No. 1064. USNM Type 74849. Here designated.

This species was originally described from 16 females and 7 males including a 'paratype' of each sex. In addition to the lectotype there are 11 female and 6 male paralectotypes in the USNM and 1 female paralectotype in the BMNH.

Liothrips ordinarius Hood, 1919 (46):101.

Lectotype ♀ *(macr.)*.—INDIA: Coimbatore (T. V. Ramakrishna Ayyar). On shoots of *Sesbania grandiflora*. Hood No. 368. USNM Type 74655. Here designated.

This species was originally described from 4 females and 12 males including a 'paratype' of each sex. In addition to the lectotype there are 1 female and 8 male paralectotypes in the USNM.

Liothrips penetralis Hood, 1935 (92):95–97.

Lectotype ♀ *(macr.)*.—PANAMÁ: Panama Canal, Barro Colorado Island, Gatun Lake, 9 August 1933 (J. D. Hood). Leaves, probably of *Trichilia* sp. Hood No. 1046. USNM Type 74835. Here designated.

This species was originally described from 9 females and 7 males including a 'paratype' of each sex. In addition to the lectotype there are 4 female and 6 male paralectotypes in the USNM and 1 female paralectotype in the BMNH.

Liothrips tupac Hood, 1938 (122):414–417.

Lectotype ♀ (macr.).—PERU: Vicinity of Celedin, Dept. Cajamarca (in Andes), 1–3 June 1936 (F. Woytkowski). Beating bush, often containing dry branches with moss. Hood No. 1187. USNM Type 74836. Here designated.

This species was originally described from 4 females and 1 male including a male 'allotype' and female 'paratype.' In addition to the lectotype there are 2 female and 1 male paralectotypes in the USNM.

Liothrips vigilax Hood, 1938 (122):407–409.

Holotype ♀ (macr.).—PERU: Vicinity of Celedin, Dept. Cajamarca (in Andes), 1–3 June 1936 (F. Woytkowski). Beating bush, often containing dry branches with moss. Hood No. 1187. USNM Type 74833.

The type-series is labelled 'vigilans' rather than 'vigilax.'

Liothrips xanthocerus Hood, 1927 (69):203.

Lectotype ♀ (macr.).—USA: Arizona, Maricopa County, Gillespie Dam, 26 August 1927 (J. D. Hood). Among terminal leaves of *Tessaria sericea* (Nutt.) T. & G. Hood No. 888. USNM Type 71239. Designated by O'Neill, Arnaud and Lee (1971:25).

This species was originally described from an unspecified number of macr. males and females. In addition to the lectotype there are 8 female and 17 male paralectotypes in the USNM and 2 female paralectotypes in the BMNH.

Lissothrips flavidus Hood, 1960 (175):65–66.

Holotype ♀ (apt.).—BRAZIL: Santa Catarina, Nova Teutonia, May 1957 (F. Plaumann). Litter. Hood No. 2939. USNM Type 72624.

This species was originally described from 6 apt. females. There was an unlabelled series of 8 apt. females in the USNM (1 apt. female is now in the BMNH). All of these bear the published type-data and moreover 1 specimen is labelled '*Lisso. flavidus* HOLOTYPE.' I have labelled all 8 apt. females as type-material.

Lissothrips muscorum Hood, 1908 (1):365.

Lectotype ♀ (apt.).—USA: Illinois, Urbana, Augerville Woods, 19 October 1907 (H. E. Ewing and J. D. Hood). Sifted by Mr. Ewing from moss on stump. USNM Type 74858. Here designated.

This species was originally described from 'several apt. females' from Illinois. In addition to the lectotype there are 11 apt. female paralectotypes in the USNM.

Macrophthalmothrips helenae Hood, 1934 (88):79–81.

Holotype ♀ (macr.).—PANAMÁ: Panama Canal, Barro Colorado Island, 29 July 1933 (J. Zetek and J. D. Hood). Dead branches. Hood No. 1019. USNM Type 71240.

This species was originally described from 34 females and 3 males 'all taken from dead branches on Barro Colorado Island, Canal Zone (type-locality) and at Porto Bello, Panamá.' This reference and the reference to 'holotypes and allotypes' and 'paratypes' in the introduction of this paper are interpreted here as a holotype designation. The designation of a lectotype by O'Neill, Arnaud and Lee (1971) is considered here unnecessary.

Malacothrips fasciatus Hood, 1952 (146):150.

Lectotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, 15 May 1949 (F. Plaumann). Grass; *Erianthus.* Hood No. 2037. USNM Type 74869. Here designated.

This species was originally described from '9♀♀ (3 of them macropterous) and 2♂♂ (brachypterous).' In addition to the lectotype there are 2 macr. female, 2 brach. female and 1 brach. male paralectotypes in the USNM.

Malacothrips mediator Hood, 1952 (146):151.

Lectotype ♀ (brach.).—BRAZIL: Santa Catarina, Nova Teutonia, 24 May 1949 (F. Plaumann). Grasses. Hood No. 2043. USNM Type 74870. Here designated.

This species was originally described from 2 females with identical data. Both are in the USNM.

Megalothrips picticornis Hood, 1927 (69):204.

Lectotype ♀ (macr.).—USA: California, 27 July 1927 (J. D. Hood). Beating *Lonicera involucrata* and dead *Salix.* Hood No. 706. USNM Type 75049. Here designated.

This species was originally described from an unspecified number of females and males from California and Utah. In addition to the lectotype there are 1 macr. female and 1 macr. male paralectotypes in the USNM.

Megalothrips (?) *spinosus* Hood, 1908 (2):306–307.

Lectotype ♀ (macr.).—USA: Pennsylvania, Harrisburg. 10 March (Pa. State Dept. Agric. Div. Zool.). In burrows of lepidopterous or coleopterous larvae in dead willow stem. USNM Type 75048. Here designated.

This species was originally described from '2 macr. females.' However, in addition to the lectotype there are 2 females labelled 'paratype' in the USNM both with data identical to the lectotype. One of these was drawn and this is regarded as a paralectotype.

Neothrips corticis Hood, 1908 (1):372.

Lectotype ♀ (brach.).—USA: Illinois, Urbana, (University forest), 18 January 1908 (J. D. Hood). Under bark on soft maple tree. USNM Type 74874. Here designated.

This species was originally described from 'several specimens of both sexes.' In addition to the lectotype there are 7 female and 5 male paralectotypes in the USNM and 1 female paralectotype in the BMNH.

Neurothrips frontalis Hood, 1952 (146):155.

Lectotype ♀ (macr.).—BRAZIL: São Paulo, Boracea, Munic de Salesopolis, 5 June 1948 (J. D. Hood). Dead branches with leaves. Hood No. 1578. USNM Type 74876. Here designated.

This species was originally described from 1 female and 4 males from Boracea, Brazil. In addition to the lectotype there are 3 male paralectotypes in the USNM.

Oedaleothrips brasiliensis Hood, 1952 (146):166–167.

Lectotype ♀ (apt.).—BRAZIL: São Paulo, Serra da Contareira, Franco da Rocha, 11 June 1948 (J. D. Hood, F. Lane and L. T. Filha). From grasses, including *Andropogon* (probably *condensatus* Kurth.). Hood No. 1606. USNM Type 75092. Here designated.

This species was originally described from 15 females, 15 males and 6 nymphs with identical data. In addition to the lectotype there are 11 female, 11 male and 6 nymphal paralectotypes in the USNM and 1 female and 1 male paralectotypes in the BMNH.

Oedaleothrips congoensis Hood, 1952 (142):204–209.

Lectotype ♀ (apt.).—CONGO BELGE: Nat. Parc Albert, Rwindi Camp, 4 December 1948 (R. S. Bradley). Grass. Hood No. 1722. USNM Type 74999. Here designated.

This species was originally described from 12 females and 7 males including a 'paratype' of each sex. In addition to the lectotype there are 5 apt. female and 5 apt. male paralectotypes in the USNM and 1 apt. female paralectotype in the BMNH.

Orthothrips leptura Hood, 1952 (146):151.

Lectotype ♀ (macr.).—BRAZIL: Pará, Belém, (Instituto Agronomico do Norte), 9 August 1951 (J. D. Hood). Dead leaves of *Astrocaryum mumbaca.* Hood No. 2682. USNM Type 74882. Here designated.

This species was originally described from 1 female and 3 males. In addition to the lectotype there are 2 brach. male paralectotypes in the USNM.

Palinothrips palustris Hood, 1952 (146):168.

Lectotype ♀ *(macr.).*—BRAZIL: São Paulo, São Carlos, (D. P. de Sauza Dias), 21 June 1950. Grass. Hood No. 1255. USNM Type 75028. Here designated.

This species was originally described from 3 females and 6 males. In addition to the lectotype there are 4 female paralectotypes in the USNM.

Phloeothrips vittatus Hood, 1912 (6):11–12.

Lectotype ♂ *(macr.).*—USA: Michigan, Baldwin, ("Star Lake" near Rainbow), 17 August 1908 (J. D. Hood). On rotting poplar stump. USNM Type 74878. Here designated.

This species was described from 2 macr. males. Both specimens are in the USNM.

Phyllothrips citricornis Hood, 1908 (2):305.

Lectotype ♀ *(macr.).*—USA: Illinois, Dubois, 5 May 1908 (L. M. Smith). On hickory leaves. USNM Type 74842. Here designated.

This species was originally described from an unspecified number of females from Illinois and Pennsylvania. In addition to the lectotype there are 8 female paralectotypes and 3 males labelled 'paratype' in the USNM and 1 female paralectotype in the BMNH.

Phyllothrips umbripennis Hood, 1909 (4):30–31.

Lectotype ♀ *(macr.).*—USA: Illinois, Carbondale, 12 October 1908 (L. M. Smith). "Jarred from post oak." USNM Type 71241. Designated by O'Neill, Arnaud and Lee (1971:25).

This species was originally described from 'many specimens of both sexes.' In addition to the lectotype there are 13 female and 10 male paralectotypes in the USNM and 2 female paralectotypes in the BMNH.

Plectrothrips antennatus Hood, 1908 (1):370–371.

Lectotype ♀ *(macr.).*—USA: Illinois, Urbana, 23 June 1908 (J. D. Hood). On outside of woodshed window. USNM Type 74893. Here designated.

This species was originally described from 2 females and 5 males. In addition to the lectotype there are 1 female and 3 male paralectotypes in the USNM and 1 male paralectotype in the BMNH.

Plemmelothrips defectus Hood, 1957 (170):144–145.

Holotype ♀ *(macr.).*—BRAZIL: Santa Catarina, Nova Teutonia, February

1954 (F. Plaumann). Under fallen leaves. Hood No. 2950. USNM Type 74183.

This species was originally described from 4 macr. females, 15 brach. females and 11 brach. males. None of these were labelled as *Plemmelothrips defectus* Hood. The holotype was labelled in ink on the glass slide 'Plemmelothrips deficiens.' An associated label bears 'deficiens' and this has been struck through and replaced by 'defectus.' There is no doubt that the specimens represent the type-series of *defectus* Hood, and I have labelled them as such.

Priesneriella citricauda Hood, 1927 (69):199.

Lectotype ♀ (apt.).—USA: California, Palo Alto, 4 August 1927 (J. D. Hood). Beating dead branches of *Salix* sp. Hood No. 744. USNM Type 71242. Designated by O'Neill, Arnaud and Lee (1971:25).

This species was originally described from an unspecified number of apt. males and females. In addition to the lectotype there are 10 apt. female and 10 apt. male paralectotypes in the USNM and 2 apt. female paralectotypes in the BMNH.

Pygothrips albiceps Hood, 1938 (116):401–402.

Lectotype ♀ (macr.).—USA: Florida, Homestead, 28 December 1927 (J. C. Bradley and J. D. Hood). Under bark on dead branches. USNM Type 75061. Here designated.

This species was originally described from 5 macr. females and 1 apt. male from Florida.

Rhopalothrips bicolor Hood, 1912 (7):73–74.

Lectotype ♀ (brach.).—MEXICO: Topo, Chico, 4 July 1908 (C. A. Hart). On leaves of *Opuntia*. USNM Type 74622. Here designated.

This species was originally described from 49 brach. females including a 'paratype.' In addition to the lectotype there are 27 brach. female paralectotypes in the USNM and 3 brach. female paralectotypes in the BMNH.

Rhynchothrips capnodes Hood, 1955 (163):106–108.

Holotype ♀ (macr.).—BRAZIL: São Paulo, Boracea, Munic de Salesopolis (elevation 850 m), 8 July 1948 (J. D. Hood). From dead branches on ground. Hood No. 1598. USNM Type 74239.

This species was originally described from a unique female holotype. This was originally labelled 'pullatus' but this name has been struck through by someone and 'capnodes' has been written below it.

Rhynchothrips rostratus Hood, 1927 (69):203.

Lectotype ♀ (macr.).—USA: Arizona, Nogales, (Pajarita Mountains), 31

August 1927 (J. D. Hood). On oak. Hood No. 912. USNM Type 74920. Here designated.

This species was originally described from an unspecified number of females and males. In addition to the lectotype female there are 1 macr. female and 2 macr. male paralectotypes in the USNM.

Saurothrips assai Hood, 1952 (146):171–172.

Lectotype ♀ (macr.).—BRAZIL: Pará, Belém, (Instituto Agronomico do Norte), 11 August 1951 (J. D. Hood). Dead leaves of *Euterpe olearacea.* Hood No. 2697. USNM Type 74823. Here designated.

This species was originally described from 11 macr. females and 9 macr. males. In addition to the lectotype there are 8 macr. female and 8 macr. male paralectotypes in the USNM.

Scopaeothrips unicolor Hood, 1912 (7):71–72.

Lectotype ♀ (brach.).—USA: Texas, Brownsville, (South Texas Garden), 29 June 1908 (C. A. Hart). On *Opuntia.* USNM Type 74619. Here designated.

This species was originally described from 'an excellent series of both sexes.' In addition to the lectotype there are 10 brach. female and 8 brach. male paralectotypes in the USNM and 4 brach. female and 12 brach. male paralectotypes in the BMNH.

Sedulothrips tristis Hood, 1934 (87):434.

Lectotype ♀ (macr.).—PANAMÁ: Canal Zone, Barro Colorado Island, 4 July 1933 (J. D. Hood). Dead leaves and branches of pomarosa (*Eugenia jambos* L.). Hood No. 971. USNM Type 71243. Designated by O'Neill, Arnaud and Lee (1971).

This species was originally described from 24 females and 10 males 'taken on Barro Colorado Island (type-locality) Canal Zone and at Porto Bello, Panamá.'

Smicrothrips particula Hood, 1952 (146):173–174.

Lectotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, 17 February 1949 (F. Plaumann). On *Lantana.* Hood No. 2036. USNM Type No. 74818. Here designated.

This species was originally described from an unspecified number of females. In addition to the lectotype there are 4 macr. female (including 1 dealate female) paralectotypes in the USNM.

Sophiothrips comptus Hood, 1955 (163):69–72.

Holotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, February 1950 (F. Plaumann). No further data. Hood No. 2084. USNM Type 74254.

This species was originally described from a unique holotype female. This specimen was originally labelled 'pictus' but someone has struck this name through and has written 'comptus' below it.

Sophiothrips panamensis Hood, 1934 (87):428–429.

Lectotype ♀ *(macr.)*.—PANAMÁ: Porto Bello, 10 July 1933 (J. D. Hood). Under bark on dead branches. Hood No. 989. USNM Type 74930. Here designated.

This species was originally described from 2 macr. females and 1 brach. female from Panamá.

Sophiothrips squamosus Hood, 1934 (87):426–428.

Lectotype ♀ *(macr.)*.—PANAMÁ: Porto Bello, 1933 (J. D. Hood). Under bark on dead branches. USNM Type 74926. Here designated.

This species was originally described from 3 macr. females, 7 brach. females, 2 brach. males and 8 brach. males from Panamá.

Stephanothrips bradleyi Hood, 1927 (69):204.

Lectotype ♀ *(apt.)*.—USA: California, Palo Alto, 4 August 1927 (J. D. Hood). Beating dead branches of *Salix* sp. Hood No. 744. USNM Type 74615. Here designated.

This species was originally described from an unspecified number of apt. males and females. In addition to the lectotype there are 2 apt. female and 8 apt. male paralectotypes in the USNM and 2 apt. male paralectotypes in the BMNH.

Stephanothrips carolina Hood, 1938 (119):366–367.

Lectotype ♀ *(apt.)*.—USA: North Carolina, Rocky Point, (Pender Co.), 21 October 1937 (R. W. Leiby and J. D. Hood). Dead branches of sweet gum. USNM 74616. Here designated.

This species was originally described from 24 apt. females and 1 apt. male including a female 'paratype' and a male 'allotype.' In addition to the lectotype there are 18 apt. female and 1 apt. male paralectotypes in the USNM and 1 apt. female paralectotype in the BMNH.

Strepterothrips conradi Hood, 1934 (87):431–434.

Lectotype ♀ *(macr.)*.—PANAMÁ: Canal Zone, Barro Colorado Island, 9 July 1933 (J. D. Hood and J. Zetek). Dead vegetation. Hood No. 987. USNM Type 71244. Designated by O'Neill, Arnaud and Lee (1971).

This species was originally described from 52 females and 15 males from 'dead branches of various species of trees and vines.'

Symphyothrips caliginosus Hood, 1952 (146):163–164.

Lectotype ♀ *(macr.)*.—BRAZIL: Santa Catarina, Nova Teutonia, 13 January 1949 (F. Plaumann). Dry branches. Hood No. 2018-H. USNM Type 74735. Here designated.

This species was originally described from 3 females. In addition to the lectotype there is 1 macr. female paralectotype in the USNM.

Terthrothrips bullifer Hood, 1957 (170):149–150.

Holotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, May 1953 (F. Plaumann). Under fallen leaves. Hood No. 2112. USNM Type 74177.

This species was originally described from 2 macr. females, 1 macr. male, 1 brach. male and 1 other male. The type-series in the USNM comprises all of these except the odd male of unknown morph. The holotype was labelled 'Terthrothrips calcaratus' in ink on the glass slide. An associated card however is labelled 'Terthrothrips bullifer,' there is no doubt that the specimens represent the type-series of *bullifer* Hood, and I have labelled them as such.

Terthrothrips carens Hood, 1957 (170):147–148.

Holotype ♀ (macr.).—BRAZIL: Santa Catarina, Nova Teutonia, April 1954 (F. Plaumann). Under fallen leaves. Hood No. 2947. USNM Type 74181.

This species was originally described from 3 macr. females and 5 macr. males. There are 2 macr. females and 4 macr. males in the USNM and 1 macr. female in the BMNH. None of these were labelled as *carens* Hood. The holotype and an associated paper label both bear 'caritus.' There is no doubt however that these specimens represent the type-series of *carens* Hood, and I have labelled them as such.

Terthrothrips hebes Hood, 1957 (170):152–153.

Holotype ♀ (brach.).—BRAZIL: Santa Catarina, Nova Teutonia, February 1954 (F. Plaumann). Under fallen leaves. Hood No. 2950. USNM Type 74173.

This species was originally described from 6 brach. females and 4 brach. males. The type-series in the USNM comprises only 5 brach. females and 3 brach. males, and none of these were labelled as *Terthrothrips hebes* Hood. An associated card is labelled 'Terthrothrips hebetatus' Hood. However the data on the slides correspond with the published data of *hebes* and there is no doubt that these specimens represent that species. Two of the specimens were labelled 'HOLOTYPE' and 'ALLOTYPE' respectively. All of the specimens of the type-series have now been labelled as *hebes* Hood. There is also 1 female paratype in the BMNH.

Trachythrips albipes Hood, 1933 (84):214.

Lectotype ♀ (apt.).—PANAMÁ: Panama Canal, Barro Colorado Island, Gatun Lake, 29 July 1933 (J. D. Hood and J. Zetek). Dead branches. Hood No. 1018. USNM Type 74617. Here designated.

This species was originally described from 'many mounted specimens of which several are males.' In addition to the lectotype there are 28 apt. female and 3 apt. male paralectotypes in the USNM and 1 apt. female paralectotype in the BMNH.

Trachythrips deleoni Hood, 1933 (84):213–214.

Lectotype ♀ (apt.).—PANAMÁ: Porto Bello, 9 July 1933 (J. D. Hood). Dead vegetation. Hood No. 987. USNM Type 71245. Designated by O'Neill, Arnaud and Lee (1971:26).

This species was originally described from 35 apt. females and 11 apt. males. In addition to the lectotype there are 27 apt. female and 8 apt. male paralectotypes in the USNM and 1 apt. female and 1 apt. male paralectotypes in the BMNH.

Trachythrips frontalis Hood, 1933 (84):214–215.

Lectotype ♀ (apt.).—PANAMÁ: Canal Zone, Frijoles, 7 July 1933 (J. D. Hood). Dead vine and bush. Hood No. 981. USNM Type 71246. Designated by O'Neill, Arnaud and Lee (1971:26).

This species was originally described from a 'large number of . . . specimens of which several are male.' In addition to the lectotype there are 28 apt. female and 2 apt. male paralectotypes in the USNM and 1 apt. female paralectotype in the BMNH.

Trachythrips seminole Hood, 1939 (125):613–615.

Holotype ♀ (apt.).—USA: Florida, Matheson Hammock, (near Miami), 30 December 1937 (J. D. Hood). Among dead fallen leaves. Hood No. 1377. USNM Type 74621.

Hood (1939 (125)) described *Trachythrips seminole* as a new species and then in the same paper treated it as a new name for an unnamed variety of *watsoni*. Bailey (1949) refers to this as *watsoni* var. *fairchildi* Watson, 1939.

Trichinothrips latifrons Hood, 1955 (163):83–84.

Holotype ♀ (macr.).—BRAZIL: São Paulo, São Carlos, at Fazenda Salto (elevation about 837 m), 14 June 1948 (J. D. Hood and D. P. de Souza Dias). Dead and dying branches of orange trees. Hood No. 1624. USNM Type 74248.

This species was described from a unique holotype female from 'BRAZIL São Carlos, S.P. 14 June 1948, J.D.H. . . . from dead and dying branches of orange trees.' There is a single slide, bearing the data cited for the holotype above, in the USNM. Apart from the data label this slide bears only the word 'HOLOTYPE 1.' An associated card bears the name 'Trichinothrips frontalis.' There is little doubt however that this specimen is the unique holotype of *latifrons* Hood, and I have labelled it as such.

Trichothrips americanus Hood, 1908 (1):366–367.

Lectotype ♀ (brach.).—USA: Illinois, Homer, (University forest), 20 March 1907 (J. D. Hood). Under bark on rotten maple stump. USNM Type 74777. Here designated.

This species was originally described from 'several specimens from Carbondale, Homer and Urbana, Illinois.' In addition to the lectotype there are 5 macr. female, 25 brach. female and 4 brach. male paralectotypes in the USNM and 2 brach. female and 1 brach. male paralectotypes in the BMNH.

Trichothrips angusticeps Hood, 1908 (1):36.

Lectotype ♀ (brach.).—USA: Illinois, St. Joseph, 4 May 1907 (C. A. Hart and J. D. Hood). Under bark on rotten oak stump. USNM Type 74779. Here designated.

This species was originally described from 7 brach. females and 1 brach. male. In addition to the lectotype there are 3 brach. female and 1 brach. male paralectotypes in the USNM.

Trichothrips anomocerus Hood, 1912 (8):137–142.

Lectotype ♀ (brach.).—USA: Maryland, Plummer's Island, (near Washington, D.C.), 18 February 1912 (W. L. McAtee). Under sycamore bark. USNM Type 71247. Designated by O'Neill, Arnaud and Lee (1971:26).

This species was originally described from 15 brach. females and 7 brach. males. In addition to the lectotype there are 7 brach. female and 7 brach. male paralectotypes in the USNM.

Trichothrips buffae Hood, 1908 (1):369.

Lectotype ♀ (brach.).—USA: Illinois, Decatur, 22 February 1908 (J. Zetek and F. C. Gates). Under bark on soft maple tree. USNM Type 74925. Here designated.

This species was originally described from 'several brachypterous specimens of both sexes . . . from Homer, Decatur and Urbana, Illinois.' In addition to the lectotype there are 4 brach. female and 2 brach. male paralectotypes in the USNM.

Trichothrips graminis Hood, 1934 (87):409–410.

Lectotype ♀ (macr.).—PANAMÁ: Canal Zone, (J. D. Hood). *Panicum maximum*. USNM Type 74793. Here designated.

This species was originally described from 3 macr. females, 9 brach. females and 2 brach. males from Panamá.

Trichothrips longitubus Hood, 1908 (1):368.

Lectotype ♀ *(macr.)*.—USA: Illinois, Carbondale, 19 May 1908 (C. A. Hart). Sweepings along railroad track. USNM Type 74830. Here designated.

This species was originally described from 9 macr. females and 1 macr. male. In addition to the lectotype there are 3 macr. female and 1 macr. male paralectotypes in the USNM.

Trichothrips mediamericanus Hood, 1934 (87):138–139.

Lectotype ♀ *(macr.)*.—PANAMÁ: Porto Bello, 11 July 1933 (S. J. Hook, H. H. Hood, J. D. Hood and J. Zetek). Dead branches of cacao. Hood No. 990. USNM Type 71248. Designated by O'Neill, Arnaud and Lee (1971).

This species was originally described from a 'large number of specimens of both sexes taken at Porto Bello, Panamá (type-locality) on Barro Colorado Island and at Frijoles.'

Trichothrips militaris Hood, 1935 (87):411.

Lectotype ♀ *(macr.)*.—PANAMÁ: Canal Zone, Barro Colorado Island, July 1933 (J. D. Hood). Dead branches. USNM Type 74785. Here designated.

This species was originally described from 5 macr. females from Barro Colorado Island and Porto Bello, Panamá.

Trichothrips smithi Hood, 1909 (4):29–30.

Lectotype ♀ *(apt.)*.—USA: Illinois, Bosky Dell, 20 October 1908 (L. M. Smith). "Jarred from hard maple branch." USNM Type 74965. Here designated.

This species was originally described from 2 apt. females. Both are in the USNM.

Zeugmatothrips badiipes Hood, 1937 (108):292–295.

Lectotype ♀ *(macr.)*.—PERU: Quayabamba, Departamento de Amazonas, (elevation about 1,300 m), 14–19 August 1936 (F. Woytkowski). Dead branches. Hood No. 1134. USNM Type 75074. Here designated.

This species was originally described from 6 macr. females and 3 macr. males. In addition to the lectotype there are 3 macr. female and 3 macr. male paralectotypes in the USNM and 1 macr. female paralectotype in the BMNH.

Zeugmatothrips cinctus Hood, 1952 (146):170.

Lectotype ♀ *(macr.)*.—BRAZIL: Pará, Belém, (Instituto Agronomico do Norte), 14 August 1951 (J. D. Hood and J. M. Pires). Dead leaves of *Astrocaryum murumuru*. Hood No. 2703. USNM Type 75082. Here designated.

This species was originally described from 16 females and 11 males from dead leaves of several genera of palms. In addition to the lectotype there are 11 macr. female and 7 macr. male paralectotypes in the USNM and 1 macr. female paralectotype in the BMNH.

Zeugmatothrips mumbaca Hood, 1952 (146):169–170.

Lectotype ♀ (macr.).—BRAZIL: Pará, Belém, (Instituto Agronomico do Norte), 11 August 1951 (J. D. Hood). Dead leaves of *Asterocaryum mumbaca.* Hood No. 2696. USNM Type 75075. Here designated.

This species was originally described from 9 macr. females and 7 macr. males. In addition to the lectotype there are 5 macr. female and 5 macr. male paralectotypes in the USNM and 1 macr. female and 1 macr. male paralectotypes in the BMNH.

Zeugmatothrips niger Hood, 1952 (146):168–169.

Lectotype ♀ (macr.).—BRAZIL: Pará, Belém, (Instituto Agronomico do Norte), 6 August 1951 (J. D. Hood). Dead leaves of *Euterpe oleracea.* Hood No. 2673. USNM Type 75079. Here designated.

This species was originally described from 10 macr. females and 3 macr. males. In addition to the lectotype there are 5 macr. female and 2 macr. male paralectotypes in the USNM and 1 macr. female in the BMNH.

Zygothrips americanus Hood, 1912 (9):114–115.

Lectotype ♀ (brach.).—USA: Illinois. USNM Type 74721. Here designated.

This species was originally described from 50 brach. females, 3 macr. females and 10 brach. males from various localities in Illinois, Michigan, Missouri, Nebraska and Maryland.

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HABITATS OF LARVAL TABANIDAE (DIPTERA) IN SOUTH TEXAS[1]

Patrick H. Thompson, Edward J. Gregg, Donald R. Charanza,
Ralph A. Sauseda and Joseph W. Holmes, Jr.

Abstract.—Through the use of physical and chemical methods, the habitats and interspecific associations of 12 species of Tabanidae in SE Texas are described. The Navasota River floodplain near College Station was the most prolific source, producing 298 larvae in 28 soil treatments with pyrethroid emulsions applied 29 March–12 August 1976. Five species were represented in the sample population of larvae here: *Tabanus atratus* F., 41.8%; *T. proximus* Walker, 36.8%; *T. subsimilis subsimilis* Bellardi, 14.4%; *T. trimaculatus* Palisot de Beauvois, 5.6%; and *T. lineola* F., 1.4%. This total of five species comprised less than one-fifth of the 26 species taken as adults by Gressitt Traps the previous season (1975); among the 21 species not collected as larvae in 1976 were numerous forms comprising up to 8.3% of the adult sample population. Conversely, the most abundant species represented in larval collections was *T. atratus*, a form including only 0.1% (14 specimens) of the adults collected in 1975. Larvae of one or two species predominated at any given site and time, with only several specimens of a 2nd or 3rd species being found under these conditions. Low indices of affinity suggest that no specific association existed between larvae of any two species found together.

The data on larvae reported here were taken in conjunction with those of adults published for several ecosystems of SE Texas; coastal marshes (Thompson, 1973a); coastal prairies (Thompson, Blume and Aga, 1977); the Pine Belt (Thompson, 1973b, 1974b, 1976); and the Post Oak Belt (Thompson, 1974a, 1976, 1977). Because of the kinds of ecosystems selected and the collecting methods used, these initial studies were not very productive. Then the discovery of larvae of *Tabanus subsimilis subsimilis* Bellardi in varied upland soil situations, and the subsequent successful use of pyrethrin emulsions for collecting this species for rearing purposes (Thompson, 1975), stimulated further application of this insecticide formulation for locating larval populations of Tabanidae. Use of pyrethrins improved productivity—i.e., more larvae were removed from larger areas in less time—and surveys, rather than collections, became the major effort.

During the last two years then, larval populations were sampled in ecosystems which demonstrated large populations of Tabanidae in previous research with adults, which were located near the laboratory and which provided soils where intoxicated larvae could be seen after surfacing. The latter criterion required that surface treatments be made in soils lacking the dense sod of marshes and grasslands or pasture and lawn turfs. Therefore, the forest floors of a river floodplain and an upland wooded ridge some 12 mi away provided the most suitable substrata for application of pyrethrin emulsions. This paper presents data based upon these collections, and others using mechanical methods, from south Texas study areas.

The Study Areas

The physiography and vegetation of the two primary study areas near College Station were described by Thompson (1974a, 1977). Briefly, the upland locality is a ridge of home properties and adjoining woodlots, the latter consisting largely of post oaks (*Quercus stellata* Wang.) on the ridges proper, and water oaks (*Q. nigra* L.) in the gullies and washes. The brushy shrub understory consists mostly of yaupon (*Ilex vomitoria* Ait.) and dense lianas. Some 12 miles away, the Navasota River floodplain forms a 2-mile-wide basin overlain with three natural vegetative cover types: Upland Forest, like that previously described, on the upper slopes and flats; Transition Forest on the basal slopes below; and Bottomland Forest on the floodplain proper. These forests are comprised of woody plant communities, the nine dominant overstory species of which form a continuum, gradually replacing one another from the uplands onto the floodplain, and then to the river margin, and are: post oak, black hickory (*Carya texana* Buckl.), winged elm (*Ulmus alata* Michx.), overcup oak (*Quercus lyrata* Walt.), willow oak (*Q. phellos* L.), cedar elm (*Ulmus crassifolia* Nutt.), water elm (*Planera aquatica* Gmel.), swamp privet (*Forestiera acuminata* (Michx.) Poir.), and black willow (*Salix nigra* L.). The topography of these lowlands is frequently flooded for short periods and occasionally, for weeks or months.

Methods

Initial studies employed a variety of mechanical devices and methods of extraction: A kitchen sieve; a modified Berlese-Tullgren Funnel apparatus; a hand cultivator for garden use; salt flotation; and a "comb" made from a wooden dowel and finishing nails (Thompson, 1970a). In the work reported here, the hemispherical kitchen sieve was replaced by one made from a stainless steel food service tray (12 × 20 × 2.5 in). The floor of the tray was cut out and covered with ¼ in mesh hardware cloth or 16-mesh wire screen—the size depending upon the texture of the soil being processed. This tray-sieve increased the volume and the sieving surface of the soil being examined and was invaluable for processing sands and alluvium in stream beds and in river floodplains. In order to find equipment for processing more soil in less time, several power-driven farm and garden implements were also used. A tractor-driven chisel was used to examine floodplain soils along the Bois d'Arc Creek (where heavy populations of *Tabanus s. subsimilis* were then seriously infesting the Red River watershed). Although no larvae were found as the gang of chisel blades cut and turned the sod to a depth of 1–2 in, the presence of earthworms and white grubs in the furrows or excavated soil showed that if numerous tabanid larvae had been present, some would have been exposed in these examinations. (Under similar circumstances—in plow furrows of cultivated fields—Davis (1919) and his colleagues found larvae of *T. sulcifrons* Macquart in Kansas, Maryland and Mississippi.) In addition to the chisel, a gasoline-driven rotary tiller was used to turn soils previously shown to contain *T. s. subsimilis*, again with negative results.

Two commercial pyrethroid formulations were used as sources of the active ingredient: An oil solution of pyrethrins (Gulfspray, Gulf Oil Corp.) which was emulsified with Triton X-100 (Rohm and Haas Co.) before addition of tap water and an emulsifiable concentrate of resmethrin (Super Syn 30EC, Redmond Chemical, Inc., Houston, Texas). After the removal of organic debris, 0.002% emulsions were applied as drenches to measured areas of soil surface. Where rainfall and evaporation allowed, 1 gal of solution per sq yd was usually sufficient to saturate mineral soils. In most cases, larvae were sought in treated plots for at least 2 h after treatment. Observations, during two treatments yielding 59 and 61 larvae of *T. s. subsimilis* (other details of study were presented by Thompson (1975)), showed that intoxicated larvae can emerge up to 18 h after treatment and that a large percentage of these, one-third to one-half, can be expected to surface after the first hour posttreatment. Several important procedures for posttreatment handling of intoxicated specimens can increase their survivorship for later rearing purposes. During the present study, up to half of those larvae emerging within the first several hours, when first washed with a mild Triton X-100 solution in water and then held in the lab at 20–25°C, were suitable for rearing in the laboratory.

Considering the temperature, pyrethroids are more active at lower temperatures down to 5°C, like DDT, whereas these materials become less effective at temperatures approximating 20–25°C. Toxicological effects, too, become very significant in affecting behavior and survival after treatment. For example, pyrethrins are more effective irritants upon insects than synthetic pyrethroids; on the other hand, synthetic pyrethroids, such as resmethrin, are more potent insecticides. Finally, in addition to their noxious effects upon insects, the dermatogenic and allergenic properties of these chemicals should be seriously considered by those persons using them.

Immatures were maintained in 2 oz clear glass jars, the Bakelite lids of which were center-drilled with 1 in holes and covered by fine-mesh metal screen. The substratum of washed builder's sand was washed with tap water weekly and the tabanid larvae were fed those of house flies and stable flies. A 14½ h photoperiod was provided with a timer-controlled 15 W fluorescent bulb.

Results and Discussion

But for the numerous larvae of *T. s. subsimilis* reported from two grassy seepage areas near domestic septic tanks (Thompson, 1975), and for lesser numbers of this species taken here in several subsequent collections, only one soil treatment in that locality produced larvae of any other species. In Thompson's four treatments totaling 81 sq ft of soil, nine larvae were recovered from the damp and leaf-littered depressions of dry-wash gullies in the adjacent post oak forest; seven of those larvae were *T. s. subsimilis* (instead of one, as previously shown in Thompson's 1975 publication). The two larvae remaining, included one specimen each of *Tabanus atratus* F. and *T. trimaculatus* Palisot de Beauvois. The only species taken by mechanical methods in other collections included one additional specimen of these two species and four specimens of *Leucotabanus annulatus* (Say). The larval habitats of these, and the other species considered here, will be described in a later section.

Lowland Locale

The most productive collections were made with pyrethrins on litter-laden soils beside standing water on the Navasota River floodplain near College Station. Of 28 treatments applied on 18 days from 29 March–12 August 1976, 23 treatments were positive for larvae. These collections yielded 285 specimens of five species and 13 more individuals of undetermined identity. Of the 298 specimens obtained, 1–38 were taken per positive treatment, with an average of 13.

Relative abundance of different species in the larval sample population and of species in the larval and adult sample populations.—In decreasing order of abundance, the five species collected as larvae were *Tabanus atratus*, *T. proximus* Walker, *T. s. subsimilis*, *T. trimaculatus*, and *T. lineola* F. (see Table 1 for numbers). These five tabanid species included only one-fifth of the 26 species taken by Gressitt Traps with CO_2 the year before (Thompson, 1977). Some of these 21 species were abundant or numerous in the adult sample population; i.e., *Tabanus sulcifrons*, *T. fuscicostatus* Hine and *Hybomitra lasiophthalma* (Macquart) comprised 8.3, 5.3 and 4.5% of that catch, respectively. On the other hand, *Tabanus proximus*, *T. s. subsimilis* and *T. lineola*, the three other species included among the six most abundant species taken as adults in 1975, were easily observed in larval collections in 1976 (Table 2). More significantly, the most abundant species represented in larval collections was *T. atratus*, a form including only 0.1% of the adults collected in 1975.

Similar results to those above, based upon adult and larval collections

Table 1. Larval samples of five species of *Tabanus* collected by pyrethroid treatments of soils on a Navasota River floodplain forest, Brazos Co., Texas, 29 March–12 August 1976 (positive treatments and identified specimens only).

Date	*atratus*	*proximus*	*subsimilis*	*trimaculatus*	*lineola*	Total
Mar. 29	3		4			7
Apr. 1	14	3				17
2			2			2
9	7	2				9
19	3	3				6
19	1	6	2	(1)[a]		10
19	8		2	1		11
May 24				1		1
24		27		2		29
24		18				18
25		3	6	4	2	15
25	1	5		1	1	8
Jun. 11		10				10
14		11		1		12
18		10	2			12
23		7				7
Aug. 2	13		2	4		19
3	8		14		1	23
4	19			2		21
4			3			3
4	7					7
9	35		3			38
12			1			1
Totals	119	105	41	16	4	285
Incidence[b]	52%	52%	48%	3%	13%	

[a] This figure represents one pupa of this species and is not included in the total of larvae below, or in any other total presented in this paper.

[b] The percentage of 23 positive collections producing the species.

in two other Coastal Plain study areas, are presented in Tables 3 and 4. Larval collections produced approximately one-quarter, or less, of the 40 species taken as adults in each study area. Based on data from the work at both the Great Swamp National Wildlife Refuge (Thompson, 1967, 1970a) and the Patuxent Wildlife Research Center (Thompson, 1970b, 1971), ranking of species demonstrated little correlation between larval and adult sample populations (Tables 3 and 4).

Larval sample populations in these ecosystems included one or two of the most abundant dominants and ignored the presence of the others. On the other hand, the one most abundant species of larva at Great Swamp and Patuxent was much less numerous in adult collections: *Tabanus marginalis* F. included less than 1% of the adult sample population (as for *T.*

Table 2. Comparison of larval sample population, Navasota River floodplain, 1976 season, with that of adults of Tabanidae from the same locale, 1975 season.[a]

	Larvae			Adults		
	Rank	%	(number)	Rank	%	(number)
Tabanus						
atratus	1	41.8	(119)	18	0.1	(14)
proximus	2	36.8	(105)	2	12.8	(1,648)
subsimilis	3	14.4	(41)	1	55.9	(7,172)
trimaculatus	4	5.6	(16)	8	2.0	(256)
lineola	5	1.4	(4)	3	4.3	(555)
21 spp. left		0	(0)		24.9	(3,195)
Totals		100	(285)		100	(12,840)

[a] Rank of adults is based upon a total of 26 species collected.

atratus at the Navasota River); and specimens representing either one or both of *T. melanocerus* Wiedemann and *T. petiolatus* Hine (the two are presently inseparable in the larval stage) dominated larval collections in a population where the adults were only commonly collected, rather than very numerous.

Density.—From 1–8 sq yds of soil surface (total = 81) were treated in those applications producing larvae. Densities ranged from 0.4–14.5 larvae per sq yd, with an average of 3.7. There was no correlation between density and the presence of standing water or the presence of leaf litter, the time of collection, the identity of the species collected, or the number of species associated together.

Interspecific association.—As mentioned previously, the most numerous species in larval collections were also the most frequent species taken

Table 3. Comparison of larval and adult sample populations of Tabanidae, Great Swamp National Wildlife Refuge, Morris Co., New Jersey 1966–1967.[a,b]

	Larvae			Adults		
	Rank	%	(number)	Rank	%	(number)
T. marginalis F.	1	80.8	(184)	17	0.3	(20)
C. vittatus Wied.	2	13.1	(30)	2	21.6	(1,394)
T. lineola F.	3	3.5	(8)	1	24.4	(1,573)
C. univittatus Macq.	4	2.6	(6)	14	0.7	(50)
36 spp. left		0	(0)		53.0	(3,434)
Totals		100	(228)		100	(6,471)

[a] Rank of adults is based upon a total of 40 species collected.

[b] Several specimens of undetermined species of *Atylotus* and *Hybomitra* are not included here.

Table 4. Comparison of larval and adult sample populations of Tabanidae, Patuxent Wildlife Research Center, Prince Georges Co., Maryland, 1968–1969.[a]

	Larvae			Adults		
	Rank	%	(number)	Rank	%	(number)
T. melanocerus Wied.;	1	44.7	(120)	14	0.7	(35)
T. petiolatus Hine[b]	—	—	—	11	4.4	(203)
C. vittatus Wied.	2	25.7	(69)	1	13.8	(648)
T. trimaculatus Palisot de Beauvois	3	18.6	(50)	8	6.3	(292)
T. lineola F.	4	3.0	(8)	9	5.6	(259)
T. sulcifrons Macq.	5	2.7	(7)	13	1.3	(64)
T. nigripes Wied.	6	2.2	(6)	23	0.1	(6)
T. marginalis F.	7	1.4	(4)	23	0.1	(6)
T. similis Macq.	8	0.7	(2)	32	>0.1	(1)
C. carbonarius Walk.	8	0.7	(2)	36	>0.1	(3)
C. dimmocki Hine	9	0.3	(1)	36	>0.1	(3)
29 spp. left		0	(0)		67.7	(3,181)
Totals		100	(269)		100	(4,701)

[a] Rank of adults is based upon a total of 40 species collected.

[b] These two species are indistinguishable in the larval stage.

then. Yet the incidence of more than two species together in any given treatment was low (6 of 23 collections or 26%). Furthermore, the use of Fager's Index of Affinity for these treatments illustrates the low frequency with which any 2 species were found together. This index equals twice the number of joint occurrences divided by the total occurrences of both species taken in all samples. Through the use of a table providing the minimum values of joint occurrence which are significant at the 0.5 level (Fager, 1957), it is possible to recognize quickly pairs of species which are decidedly associated versus those which show no evidence of affinity at all. At some later time then, additional and more specialized sampling techniques can be used to study those associations which are questionable.

With the exception of *T. lineola*, which was inadequately represented in the sampling reported here, Fager's Indices for each association are shown in Table 5; testing these indices with the table provided by Fager, no significant association was found between any two of the other four species considered here. Therefore, collection of any one of these species did not increase the chance of finding any other species associated with it.

The low Indices of Affinity found here support the idea that these tabanid species of the predominantly cannibalistic genus *Tabanus* compete fiercely for space in mutually satisfactory habitats. Also, these low Indices for the large *T. atratus* and *T. proximus* species could result more from their dominant size than from their absolute abundance (as indicated by their

Table 5. Fager's Indices of Affinity for five species of *Tabanus* associated together, Navasota River floodplain, Brazos Co., Texas, 29 March–12 August 1976.

	atratus	*proximus*	*subsimilis*	*trimaculatus*	*lineola*[a]
atratus	—	0.417	0.522	0.400	—
proximus	0.417	—	0.261	0.400	—
subsimilis	0.522	0.261	—	0.316	—
trimaculatus	0.400	0.400	0.316	—	—
lineola[a]	—	—	—	—	—

[a] This species was inadequately represented for assignment of an index.

related abundance in samples of adult insects—*T. proximus*) or their habitat specificity (both species).

Seasonal incidence.—Moving down through the chronologically-ordered list of treatments in Table 1, no striking seasonal differences are apparent in the incidence of any particular species. But for *T. trimaculatus* and *T. lineola*, the least numerous and least frequent species observed, larvae were found throughout the entire period of collection—from spring through summer. With rare exception, larvae of all species were no less than half an inch long. Although no measurements of larval lengths were made, the majority of specimens of each species taken in any given collection were similar in size; this was especially noticeable for the large species, *T. atratus* and *T. proximus*.

The Habitats

The larval stages of 12 species of Tabanidae were obtained by means of pyrethroid treatments in upland and lowland locales near College Station and by mechanical means from these and other study areas in SE Texas.

Chlorotabanus crepuscularis (Bequaert).—One larva was taken from the marginal mud of a slough at the Navasota River Bottoms (NRB), 14 September 1971. Adults of this species were rare from this and the other locales considered here.

Leucotabanus annulatus (Say).—Large larvae of this species were found in their typical habitat, rotting deadfall (4 specimens, Upland Locale, February–May collections; 1 specimen, Huntsville State Park, Walker Co., 19 June 1972).

Tabanus atratus F.—One of the most common species found; one specimen was removed from the grassy septic tank seepage area described by Thompson (1975), where it was associated with 4 larvae of *T. subsimilis subsimilis* (8 June 1976). Some 35 yds away, another larva was found at the margin of a small, shallow pond of some 500 sq ft of surface, which was choked with pickerelweed (*Pontederia*) and duckweed (*Lemna*) (17 April 1974). Also, on a ridge near this site, Christopher Thompson found a larva crawling on the soil surface—a larva which had apparently been disturbed by his deep excavations several feet away (21 March 1976). Larvae were found in shoreline situations near other standing waters (drainage ditch through a coastal marsh which was described by Thompson (1973b), 12 July 1971; and a pond on a municipal golf course, College Station, 1 April 1974). The most prolific sources were the margins of woodland pools and sloughs at NRB; four larvae were found here (in the months of January, February, June and August) before the insecticide treatments later produced 119 specimens (Table 1). Of the latter samples, 116 specimens were found in samples near standing water; the three specimens remaining were removed from a leaf-littered wash.

Tabanus cymatophorus Osten Sacken.—One larva of this large, brightly-marked fly, was taken from the marginal mud of a woodland pond at NRB. Associated with several *T. proximus* larvae nearby in this March collection, the larva was reared to the adult form (female) for determination. The incidence of *T. cymatophorus* as an immature was low compared with the commonness of the adults in 1975 (106 females, late June–early August; Thompson, 1977).

Tabanus lineola F.—This species was found in three NRB collections made with pyrethrin emulsions (Table 1).

Tabanus molestus Say.—One specimen, identified as a larva, was removed from the shoreline of a slough at NRB, 14 September 1971. Adults were not common in previous collections (30 specimens, mid-May to mid-July).

Tabanus petiolatus Hine.—Five larvae were taken from a sandy wash across a firelane in a pine-hardwood forest, Huntsville State Park in September; later in October, three larvae were found in a sandy creek bank of the same forest. Although three of these eight specimens were reared for identification, the closely related *T. melanocerus* is presently unknown from this study area. Lastly, one larva was taken with *T. trimaculatus* and three other species (see *T. trimaculatus*) from the Navasota River. It was later reared for identification.

Tabanus proximus Walker.—The most common form collected from NRB before the 1976 collections using pyrethroids; six collections in March and one in October produced 24 specimens from the margins of ponds and pools. As in later collections with pyrethroids, *T. proximus* was associated with *T. trimaculatus* and *T. atratus.*

Tabanus subsimilis subsimilis Bellardi.—Since the 1975 report, four additional collections of *T. s. subsimilis* were made in the same habitats described then: 1 pupa, in a flower bed skirting a patio and 8 larvae in a grassy alga-covered seepage area (May and June of 1976). In two June collections, one larva was found at the margin of a grassy pasture pond, surrounded by very dense willow saplings, and one larva was removed from the bank of the Navasota.

Tabanus sulicifrons Macquart.—Two specimens, identified as larvae, were taken from the marginal mud of a drainage ditch through a brackish coastal marsh near Angleton in July (habitat described in Thompson, 1973a) and from a pile of dry and duff-like manure in the corner of a hay shed near College Station in September. (Three pupal exuviae, believed to represent a sibling species, were found several inches above the bottom of a dry-wash gully in association with three pupal exuviae of *T. proximus*.)

Tabanus trimaculatus Palisot de Beauvois.—This species was represented in collections from all major locales studied: In a grassy seepage area (1 specimen) together with large numbers of *T. s. subsimilis* (Thompson, 1975); at the margin of a 2-acre impoundment with *Ludwigia* submerged along the littoral zone nearby and smartweed (*Polygonum*) at the shoreline above it (1 larva); in the sandy-creek bed of a pine-hardwood forest, the site previously described for *Tabanus petiolatus*, but on a different occasion (2 larvae); as the predominating species in marginal mud of NRB sloughs in association with *Chlorotabanus crepuscularis*, *Tabanus atratus*, *T. molestus* and *T. petiolatus* (7 specimens); at this slough and at woodland pools nearby in March of the following year, in association with 11 specimens of *T. proximus* and 1 of *T. atratus* (7 specimens); and dominating the latter species here the next October (17 specimens to 4 of *T. atratus*); and finally, again in March of the following year, from a woodland pond margin here, where 1 specimen was a small minority among the 13 *T. proximus* specimens found.

Tabanus venustus Osten Sacken.—One specimen, later reared to the adult form (female), was found in March at the margin of a small pond near the College Station municipal airport.

Conclusions

If the adults of Coastal Plain Tabanidae are ubiquitously obvious to the observer, the larvae are patently obscure. Paradoxically, this situation is occasionally reversed, with larval numbers in samples greatly exceeding those of adults: *Tabanus reinwardtii* Wiedemann (Cameron, 1926; Philip, 1931; Schwardt, 1936; Stone, 1930; and Pechuman, 1972); *T. marginalis* (Philip, 1931; Teskey, 1969; and Thompson, 1970a (q.v., Table 3)); *Merycomyia brunnea* Stone (Jones and Anthony, 1964); and *Merycomyia whitneyi* (Johnson) (Pechuman, 1964; Goodwin, 1973; and Philip, Weems, and Fairchild, 1973). In either case of adult or larval preponderance, this disparity between numbers of the two forms has complicated population estimation and retarded understanding of larval ecology.

Comprehension of tabanid larval ecology has also been obscured by the relative ease of finding larvae in marginal habitats, by the relative difficulty of finding them in deeper soils in habitats where they have been previously established and by the consequent understandable biases of scientists focusing their attentions on marginal niches and surficial soils.

This information, based upon accumulated field experience, has been reenforced by several notions originated and perpetuated in the literature—notions categorizing the immatures of Tabanidae, collectively, as aquatic or semiaquatic insects, rather than as soil insects; as specialized forms in choice of habitat niches, instead of as generalized ones; and as air-breathing insects, rather than as those depending very largely upon cutaneous respiration.

Thus biased collecting and published misconceptions regarding the larvae of the family have led to arbitrary classification of groups of species according to habitat. Usage of such terms as aquatic, littoral, submerged and terrestrial have been applied to certain species rather than to the habitats where those species were observed in specific instances. (The larvae of the so-called terrestrial species have been so described because they were found away from habitats near any accumulations of free water. Although some Tabanidae are obviously adapted morphologically for aquatic existence and others are commonly found submerged, proximity to free water probably has little causal relationship in habitat selection for most species of the Atlantic Coastal Plain of North America.)

In conclusion, the cumulative effect of this experience and these ideas in North American research has been to encourage the search for habitats which are as distinctive as the species inhabiting them and to discourage recognition and study of the critical factors limiting the distribution of tabanid larvae in general. For it is the general body of knowledge about larval habitat selection—the critical environmental characteristics many species of Tabanidae hold common—that reveals most about the biology of most of these species as individuals. To wit, the life of the generalized larval type is unknown. The large body of published larval collection data for Coastal Plain species, the most obvious habitat descriptions of which have been conveniently summarized in tabular form for 109 species and subspecies by Goodwin (1967), documents the generalized and nonspecific nature of this habitat selection.

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Veterinary Toxicology and Entomology Research Laboratory, Agric. Res. Serv., USDA, College Station, Texas 77840.

Footnote

[1] This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended.

NOTE

WILLIAM DWIGHT PIERCE, BIOGRAPHICAL NOTES AND A REVIEW OF HIS BOOK *THE DEADLY TRIANGLE*

W. Dwight Pierce, as he was often known, died nearly 11 years ago, but no obituary has come to my attention. During his long life (16 November 1881–29 April 1967) he was productive in several aspects of our science for more than 60 years. The recent appearance of his unusual book on entomological history (The Deadly Triangle. A brief history of medical and sanitary entomology. 1975. 138 pp.) makes timely both a review of the book and brief biographical notes. This small, soft-bound, posthumously and privately published book is distributed in accordance with Dr. Pierce's will by the executor of his estate, Dr. Richard B. Loomis, Department of Biology, California State University, Long Beach, California 90840. The supply is limited, but there may be a second printing.

Largely in language understood by the layman, for Dr. Pierce often lectured before general groups and felt that entomologists should do a better job explaining science to the public, he has attempted to give a broad view of the early history of science, especially the background of those diseases of man that later were found to be transmitted by arthropods. A typical "triangle," in terms of the title, is represented by a man, a mosquito, and the causative organism (*Plasmodium*) of human malaria. Much of Dr. Pierce's experience in the field of medical entomology dates from the World War I period when he headed a committee responsible for making information on entomology available to the armed forces. However, he refers (page 99) to an unpublished compilation of over 2,800 pages covering more than 500 diseases of man and animals, so the subject was of long-time interest to him.

The book lacks illustrations except for a diagram on the cover and, unfortunately, the offset type of printing is noticeably small. The writing is rather anecdotal in style, probably unsuitable for beginning students, but much background information of potential interest to advanced entomologists and sanitarians is included. About 45 pages deal with the nature of diseases in early times; then there are brief accounts of malaria and numerous other arthropod-borne diseases, with particular reference to the period when proofs of transmission were first obtained. Later, the urgent problems brought about by World War I are discussed. World War II, with its more global problems, is discussed in less detail than it deserves; for example, there is a decidedly short account of dengue, which was a serious disease on Saipan. Finally, there is an expanded discussion of 12 principles governing insect transmission of disease, a list of literature cited, index to authors and other persons mentioned, and a short subject index. A few

Dr. W. Dwight Pierce (right) shown with Dr. Paul H. Arnaud on a balcony of the Los Angeles County Museum in late 1953 (from a kodachrome by Gurney).

of the publications cited appeared as recently as the late 1950's and 1960, but a hasty check shows that Dalmat's important volume (Dalmat, H. T. 1955. The Black Flies (Diptera, Simuliidae) of Guatemala and Their Role as Vectors of Onchocerciasis. 425 pp.), Cushing's short history (Cushing, E. C.

1957. History of Entomology in World War II. 117 pp.), and Zinsser's classic work (Zinsser, H. 1934. Rats, Lice and History. 301 pp.) are omitted. More recently, several other books that cover some of the same historical aspects as Pierce's, have appeared, one of the most recent being a very attractive and readable book (Cloudsley-Thompson, J. L. 1976. Insects and History. 242 pp.).

Dwight Pierce was born in Illinois and studied entomology at the University of Nebraska where he obtained bachelor's and master's degrees. In 1917 he received the doctorate in entomology from George Washington University, Washington, D.C. He mentions that one of his first jobs was packing chinch bug fungus in Professor Lawrence Bruner's laboratory in 1901 for distribution to farmers. He was employed in 1904–1919 by the U.S. Department of Agriculture and worked on insects attacking field crops, especially cotton, as well as those affecting the health of man and animals. A 1912 paper by Pierce et al. on the relationships of a large number of insects (pests, parasites, hyperparasites, predators) directly or indirectly associated with the cotton plant was an outstanding early example of the interdependent associations of insects and plants (Pierce, W. D., R. A. Cushman and C. E. Hood. 1912. The Insect Enemies of the Cotton Boll Weevil, U.S. Dept. Agr., Bur. Entomol. Bull. 100:1–99). An instructive diagram from the paper, which illustrates the relationships of this boll weevil complex, was reproduced in a standard text (Allee, W. C., O. Park, A. E. Emerson, T. Park and K. P. Schmidt. 1949. Principles of Animal Ecology. 837 pp.) as a notable example of interspecies relationships. Pierce also became an active systematist on weevils and Strepsiptera. He was located in Washington, D.C. a portion of the time but at other times chiefly in the South. In 1917, with the assistance of about a dozen colleagues, Pierce published a book on potential harmful insect introductions (Pierce, W. D. (Ed.) 1917. A Manual of Dangerous Insects Likely to be Introduced in the United States through Importations. 256 pp.). During World War I he was a leader in several activities of the Bureau of Entomology that were planned to give full assistance in solving military problems that involved insects. He describes on page 69 how a special class of about 25 entomologists was formed, and 500 copies of the proceedings were mailed weekly to entomologists and military representatives throughout the U.S. This was the genesis of another book (Pierce, W. D. (Ed.) 1921. Sanitary Entomology. The entomology of disease, hygiene and sanitation. 518 pp.). About 10 collaborators assisted him in the book's preparation.

After leaving USDA employment, Dr. Pierce worked as a consultant, during which period he had assignments in the Philippine Islands and elsewhere, before he began serving on the staff of Biological Abstracts in 1931–1936. From 1937 he was associated with the Los Angeles County Museum in California, where he again did systematic work on a variety of insects including fossils from calcareous nodules of Miocene age found in the Calico Mountains of southern California and others from Pleistocene or more recent deposits of the Rancho La Brea asphalt pits. A second posthumous publication was issued privately (Pierce, W. D. 1975. The Sand Dune Weevils of the genus *Trigonoscuta* with a correlation of their anatomy to the Geological History of our Coast Lines. 160 pp.). A few details of Dr. Pierce's study habits during his last years are contained in the Editor's Comments of the *Trigonoscuta* paper. He continued to do some teaching and to provide consulting service. He and his wife, who also has died, had no children.

Dwight Pierce seems to have been a consistently imaginative, studious entomologist, glad to tackle new and difficult problems. Even if not always successful in an outstanding way, he made important and unforgettable contributions. In the historical account reviewed here, he tried to plant new ideas for further investigation, though some may not appear orthodox now. During his career, medical entomology developed from its infancy as a discipline into a major speciality with outstanding accomplishments of international scope. From the time of his earliest participation in this specialty, during which he was associated with L. O. Howard, W. D. Hunter, and F. C. Bishopp, he appears to have been constantly recording the background events, trying to place developments in the context of fundamental principles, and explaining the subject to both the lay public and professional workers seeking more information. Throughout his career, he was a scholarly naturalist of the old school. At the time of his death he was one of the oldest members, in both age and length of membership, of the Entomological Society of Washington.

Ashley B. Gurney, *Cooperating Scientist, Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560.*

NOTE

NEW DISTRIBUTIONAL RECORDS FOR TWO SPECIES OF *NERTHRA* SAY FROM MÉXICO (HEMIPTERA: GELASTOCORIDAE)

A small collection of Gelastocoridae from México recently identified for Dr. Harry Brailovsky A., Instituto de Biologia, México, D. F. included the following new distributional records.

Nerthra spangleri Polhemus, 1972. Proc. Entomol. Soc. Wash. 74(3):306. 2♂ and 2♀, Isla Isabel, Nayarit, México, 31 Jan. 1976. J. Palacios.

Polhemus listed Sinaloa, Sonora and Colima in the original description, so the occurrence in Nayarit is not surprising. The species will undoubtedly eventually be found in Jalisco as well.

Nerthra usingeri Todd, 1954. Pan-Pac. Entomol. 30(2):116. A single ♂ collected on the Estacion de Biologia, Chamela, Jalisco, México, 5 Dec 1976, H. Brailovsky. This is first Mexican record for the species. It was previously known only from California.

E. L. Todd, *Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA c/o NHB-127, U.S. National Museum, Washington, D.C. 20560.*

NOTE

A "NOCTURNAL" FORAGING RECORD FOR *DIOGMITES NEOTERNATUS* (DIPTERA: ASILIDAE)

Robber flies are generally considered to be diurnal insects usually being active between about 9:30 AM and 7:30 PM. However, some species, in particular those in the desert, have been observed to mate during the night (Lehr, 1959, Proc. Fourth Congr. All Union Entomol. Soc. 1:76–78; Lehr, 1964, Proc. Sci. Res. Inst. Protection Plants, Alma-Ata. 8:213–244 (In Russian); Newkirk, 1963, Ann. Entomol. Soc. Am. 56:234–236). In addition, Rau (1938, Ann. Entomol. Soc. Am. 31:540–556) reported *Deromyia ternatus* Loew foraging and capturing house-flies on a screen-door of a city shop at dusk. Presumably, this species was using the light from the shop to see and capture its prey. Since such behavior among Asilidae is infrequently reported, we would like to report the following similar "nocturnal" foraging behavior for *Diogmites neoternatus* (Bromley). It is also of interest to note that to our knowledge, this is the first published record of this asilid occurring in Virginia.

While collecting insects in the vicinity of Fairfax, Virginia, we frequently found *D. neoternatus* in open weedy fields, on the edges of forested areas and less frequently in the forests. We also found numerous specimens of this species trapped in the staircase of our three-story apartment building. *Diogmites neoternatus* have been found by other investigators in open areas of dry fields (Scarbrough, 1974, Proc. Entomol. Soc. Wash. 76:385–396), in clover fields (Artigas, 1966, Ohio J. Sci. 66:401–421), and moist bushy woods or fields (Bromley, 1931, Ohio State Univ. Mus., Sci. Bull. 1:3–19; Bromley, 1950, Ann. Entomol. Soc. Am. 43:227–239).

On 24 July 1976 at 12:15 PM, we observed several *D. neoternatus* resting on the walls of the aforementioned well-lit apartment building staircase, as well as flying about the staircase (according to Bromley, 1950, Ibid., *D. neoternatus* "has been taken at light," which may mean that this species was collected at night near a light). Much to our surprise one male captured a prey (Diptera: Xylomyidae, *Xylomya* sp.) in flight by the light of the staircase. The male then flew around with his fore legs held above his thorax in a posture similar to that exhibited by male *D. angustipennis* Loew during courtship (see Lavigne and Holland, 1969, Univ. Wyo. Agr. Exp. Stn. Sci. Monogr., No. 18, 61 pp.), held the prey between his middle and hind legs and tried to "grab" onto the walls. He eventually held onto a crevice in the wall with his left fore leg, inserted his hypopharynx in the prey and rested on the wall with all six legs. As the male fed he frequently held onto the wall with one of his fore legs, manipulated the prey with the rest of his legs and reinserted his hypopharynx. The male would then either hang onto the wall for a short period of time with one fore leg or immediately grab onto the wall with all six legs. Similar methods of manipulating prey have been observed for other species of *Diogmites* (Bromley, 1946, Bull. Conn. Geol. Nat. Hist. Surv. No. 69, 48 pp.; Lavigne and Holland, Ibid.). We continued to watch the male until we disturbed him and he dropped the prey in flight. In addition to feeding on a dipteran, as reported here, Artigas (Ibid.) states that *D. neoternatus* feeds principally on bees and wasps, and occasionally flies and "bugs."

We would like to thank R. J. Lavigne (Entomology Section, University of Wyoming, Laramie) for his confirmation of the identity of *Diogmites neoternatus*.

D. Steve Dennis and Jeanne A. Gowen, *3065 South Cathay Circle, Aurora, Colorado 80013.*

BOOK REVIEW

A Bibliography of Quantitative Ecology. 1977. V. Schultz, L. L. Eberhardt, J. M. Thomas, M. I. Cochran. 361 pages. Dowden, Hutchinson & Ross, Inc., Stroudsberg, Pennsylvania. Cost $18.50.

This bibliography includes over 2,000 references arranged in 28 topics relating to quantitative ecology including age, frequency distribution, models, sampling, and taxonomy. References are through 1974, and there are some titles from 1975. The format of the book is such that entries are arranged in two columns per page with the pages consisting of offset reproduction of camera-ready copy prepared from computer printout or what would appear to be computer printout. Within each topic the papers are arranged alphabetically by the surname of the first author. The index presented at the end includes the names of all authors. Thus, second and third authors of joint publications can be identified.

Information retrieval from the bibliography is a problem. If one wants to know something about negative binomial distributions, he will have to scan all of the titles under frequency distribution or know that C. I. Bliss, R. A. Fisher, and a few other statisticans work in the research field. A subject index would have been useful.

Some of the papers have pertinence in more than one field, but each paper is listed only once under the 28 topics. Because of the way the bibliography is arranged, it is impossible to identify a paper which tangentially approaches a topic in which the user wants more information. An in-depth cross index would have added substantially to the value of this book.

Another source of improvement would be uniform application of key words following each citation. Some references have key words added, but others do not.

Considering a topic as broad as quantitative ecology, it would be nearly impossible to prepare a complete bibliography. I suspect that the 2,000 plus references are comparable to the emergent part of an iceberg: seven-eighths of its mass remains submerged. For instance, nearly all of the references are English language papers, but there are innumerable non-English language papers on quantitative ecology.

All things considered, this is a reasonable first attempt at collecting the literature about quantitative ecology. However, in thumbing through the book I had the feeling one has when he goes to an unfamiliar library: the information is there, but how does one find it?

Gordon Gordh, *Systematic Entomology Laboratory, IIBIII, Agric. Res. Serv., USDA (present address: Division of Biological Control, Department of Entomology, University of California, Riverside, California 92502).*

SUMMARY REPORTS OF SOCIETY OFFICERS FOR 1977

Treasurer

(1 November 1976 to 31 October 1977)

SUMMARY:	General fund	Special publication fund	Total
On hand, 1 Nov. 1976	1,194.51	18,386.72	19,581.23
Total receipts	31,996.40	7,429.07	39,425.47
Total disbursements	29,607.49	887.50	30,494.99
On hand, 31 Oct. 1977	3,583.42	24,928.29	28,511.71

Editor

(Calendar Year 1977)

Four numbers of the *Proceedings* were published in 1977. The 662 pages printed represented 84 scientific articles, 16 notes, 3 book reviews, 3 announcements and the minutes for 7 meetings of the Society. Page charges were waived for 14 articles totaling approximately 74 pages. Full page charges were paid for immediate publication for 7 articles totaling 63 pages.

The January 1977 issue of the *Proceedings* was dedicated as *The Alan Stone Commemorative Issue* on the occasion of Dr. Stone's 73rd birthday. A new format for articles was instituted with the July 1977 issue. Adoption of the new format will mean that larger print will be used throughout the articles, that there will be more type/page, and that, with several minor editorial changes, the Society will realize a reduction in its printing costs. Page charges were raised to their present level in December 1975. No increase in page charges is expected at this time. Costs of reprints were raised in March 1977.

In September 1977, the Society sponsored the publication of "Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae)" by George C. Steyskal. This article is now available from the Custodian for $1.50.

Publications Committee: Earlene Armstrong, Barnard D. Burks, Ashley B. Gurney, George C. Steyskal, Manya B. Stoetzel (*Editor*).

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Cynipid Galls of the Southwest, by Lewis H. Weld	3.00
Both papers on cynipid galls	6.00
Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	.25
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver	.25
A Short History of the Entomological Society of Washington, by Ashley B. Gurney	.50
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal	1.50

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No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 1942	15.00
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 1976	11.00

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WASHINGTON

1884

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SMITHSONIAN INSTITUTION
WASHINGTON, D.C. 20560

PUBLISHED QUARTERLY

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THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

Organized March 12, 1884

OFFICERS FOR 1978

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, c/o Department of Entomology, Smithsonian Institution, Washington, D.C. 20560.

MEETINGS.—Regular meetings of the Society are held in the Ecology Theater, Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 8 P.M. Minutes of meetings are published regularly in the *Proceedings*.

MEMBERSHIP.—Members shall be persons who have demonstrated interest in the science of entomology. Annual dues for members are $9.00 (U.S. currency) of which $8.00 is for a subscription to the Proceedings of the Entomological Society of Washington for one year.

PROCEEDINGS.—Published quarterly beginning with January by the Society at Washington, D.C. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember subscriptions are $15.00 per year, domestic, and $17.00 per year, foreign (U.S. currency), payable in advance. All remittances should be made payable to *The Entomological Society of Washington*.

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80(3), 1978, pp. 317–329

DESCRIPTION AND LIFE CYCLE OF A NEW SPECIES OF *HISTIOSTOMA* (ACARI: HISTIOSTOMIDAE) ASSOCIATED WITH COMMERCIAL MUSHROOM PRODUCTION

Aagje Hill and Kenneth L. Deahl

Abstract.—The immature and adult stages of a new species of Histiostomidae, *Histiostoma heinemanni*, associated with commercial mushroom production, are described and compared with those of *H. feroniarum* (Dufour). Methods for rearing *H. heinemanni*, data on its biology and evidence that it may spread mushroom pathogens are presented.

While collecting mites from commercial mushroom beds and compost piles in Chester County, Pennsylvania, we frequently found adult and immature stages of new species of *Histiostoma*, almost identical with *H. feroniarum* (Dufour). *Histiostoma feroniarum*, which has also been found on mushrooms as well as in many other habitats, has been redescribed by Scheucher (1957), Hughes and Jackson (1958), and Jary and Stapeley (1936) under the name *Histiostoma rostro-serratum* (Megnin). Hughes (1976) synonymized *Anoetus* under *Histiostoma*. We are using her nomenclature for the idisomal structures.

This work was done in collaboration with the Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland 20705. We undertook laboratory breeding experiments to study the life-cycle of the new species of *Histiostoma* and to collect all stages so that they could be described and figured.

Methods of Rearing and Course of Development

Histiostoma species have been associated with environments with high relative humidity. Rearing experiments were started by transferring groups of hypopi to petri dishes containing potato-dextrose agar and some decaying potato that served as food. The dishes were sealed with tape to prevent the hypopi from escaping and then placed in an incubator at 27°C. Some hypopi entered the quiescent stage within a few hours after being transferred to the dishes. The first tritonymphs were seen on the 2nd day and the first eggs were seen on the 4th day. The females selected dry and compacted material on which to lay eggs, either singly or in small clusters. The first larvae were seen on the 5th day and the first protonymphs were seen on the 6th day. Without overpopulation or food depletion the hypopus stage was omitted and the first tritonymphs were seen on the 7th day. Increasing numbers of hypopi were found in dishes kept from 4–6 weeks. Like Scheucher (1957), we saw hypopi standing on legs III and IV and making searching movements with legs I and II, apparently ready to attach to the moving objects, usually insects by which they are dispersed.

Parthenogenesis experiments were like the rearing experiments except that only one hypopus was put in each petri dish. Only two of these hypopi out of approximately 30 specimens developed into adult females that laid eggs. Cultures became infested with fungi, which probably prevented the development of these stages. Eggs of one of these females gave rise to three tritonymphs, fourteen heteromorphic males and two homeomorphic males; eggs of the other gave rise to one tritonymph, twenty-two heteromorphic males and twelve homeomorphic males.

Histiostoma heinemanni Hill and Deahl, new species

Diagnosis.—The adults and immatures of *Histiostoma heinemanni* can easily be distinguished from those of other *Histiostoma* spp. by the platelet (pl) located between scapular internal setae (sci) and scapular setae (sce) (Fig. 1). Gnathosoma (Figs. 36–37): Gnathosoma identical in immatures and adults, except for size. Chelicerae (Fig. 36) bifurcate distally with 6 small teeth and laterally with 9 larger teeth; flagellum present; proximal part of digitus fixus (df) with 3 projections; digitus mobilus (dm) smaller than df. Pedipalps (p) (Fig. 37) with 2 flagella, subequal in length; membranous structure present on venter of pedipalps.

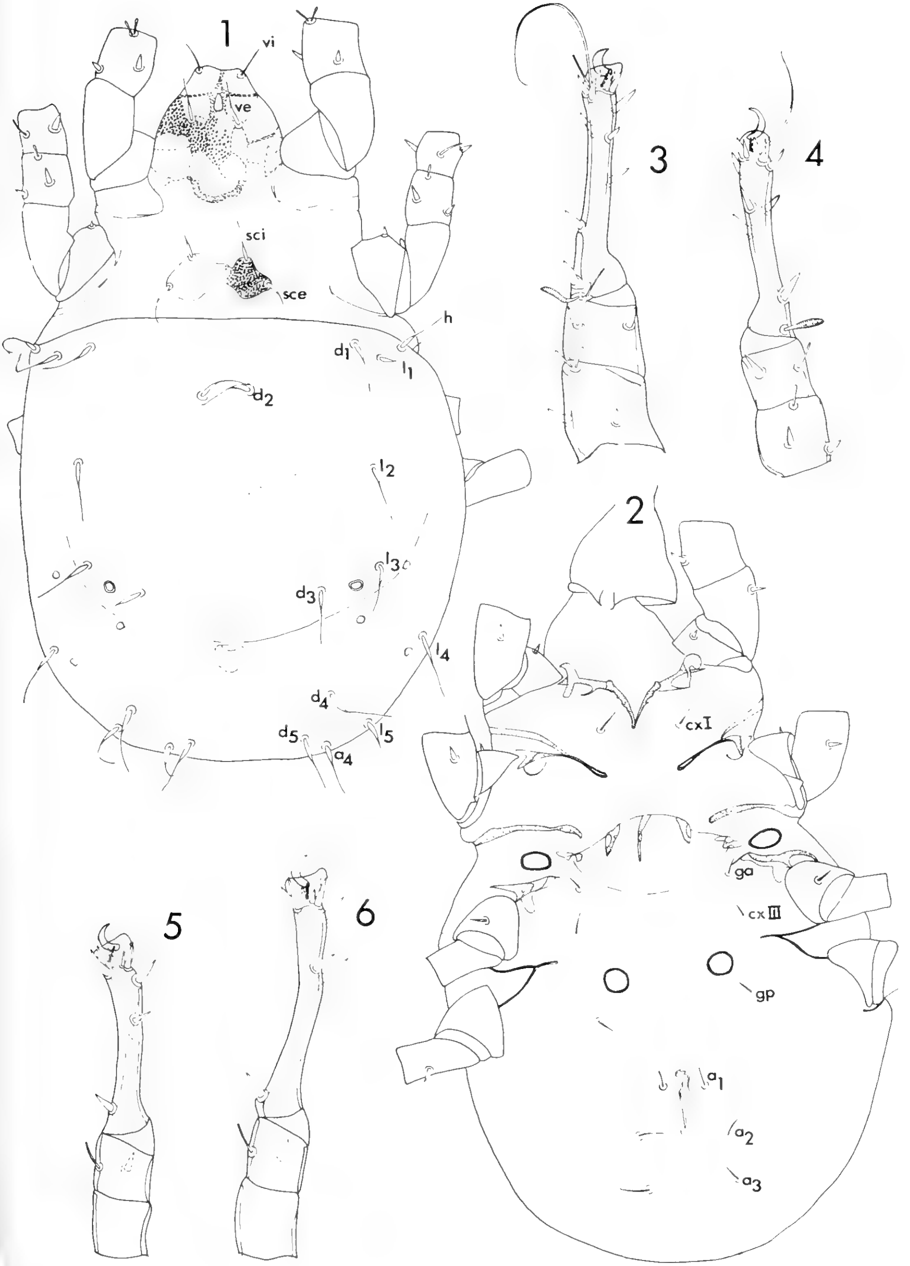
Female

Figs. 1–6

Holotype.—Idiosoma pyriform, 440 μ long and 227 μ wide; length of paratypes (10) averages 363 (279–467) μ long and 203 (147–267) μ wide; cuticle with fine projections.

Dorsum (Fig. 1).—Anterior of propodosoma sculptured; vertical internal setae (vi) in front of vertical external (ve); vi not enlarged basally; sci in front of sce; sci and sce border platelet (pl). All prodosomal setae subequal in length. Dorsal propodosoma and hysterosoma separated by transverse groove. Setae d_1, d_5, l_1–l_5 and h smooth with enlarged bases and slender distally. Oil gland between d_3 and l_3 ; 3 pores in same region. Bursa copulatrix dorsal, located about $1/6$ the length of the hysterosoma from caudal end.

Venter (Fig. 2).—Epimera I Y-shaped. Transverse genital opening between coxae II and III. Two pairs of almost circular rings, anterior pair between coxae II and III, posterior pair at level of coxae IV. Setae cx III slightly shorter and finer than cx I; setae ga and gp subequal in length and somewhat longer than $1/2$ the length of cx I; setae gp and subequal in length; setae a_2 and a_3 slightly shorter than 2× the length of a_1; a_4 (Fig. 1) slightly shorter than 3× the length of a_1.



Figs. 1–6. *Histiostoma heinemanni*, female. 1. Dorsum; 2. Venter; 3–6. Respectively, legs I–IV.

Legs (Figs. 3–6).—With 5 free segments; tarsi relatively long, with stout claw originating in short pretarsus. All setae spinelike. Chaetotaxy: Tarsi, 13-12-10-10; tibiae, 2-2-1-1; genua, 2-2-0-0; femora, 1-1-0-1; trochanters 1-1-1-0. Solenidiotaxy: Tarsi, 3-1-0-0; tibiae, 1-1-1-1; genua, 2-1-0-0. For trochanters and femora see Figs. 1 and 2.

Male
Figs. 7–12

Two types of males are present in the cultures: Homeomorphic males with normal size spines on tarsus II and heteromorphic males with two enlarged spines on tarsus II. Intermediate stages are found. Idiosoma of 8 heteromorphic males averages 298 (255–319) μ long and 147 (128–160) μ wide. Idiosoma of 7 homeomorphic males averages 262 (230–287) μ long and 127 (121–134) μ wide. Idiosoma more rectangular and smaller than in females; cuticle covered with small projections.

Dorsum (Fig. 7).—Anterior of propodosoma sculptured; setae vi in front of ve; sculptured platelet (pl) bordered by setae sci and sce. All propodosomal setae subequal in length, enlarged basally except vi slender distally. Hysterosomal setae d_1–d_5, l_1–l_5 and h correspond with those of female in relative size and distribution, but setae d_4 are absent. Oil gland between setae d_3 and l_3; pore at level of l_4.

Venter (Fig. 8).—Four chitinous ringlike structures at level of coxae IV. Arrangement of setae and epimera as in female. Genitalia located about $\frac{1}{6}$ the length of the hysterosoma from caudal end; 2 pairs of internal setae, the shorter located more dorsally, and 4 pairs of anal setae.

Legs (Figs. 9–12).—Tarsi broader and shorter than in female. Chaetotaxy and solenidiotaxy as in female, except for tarsus I, which has 10 setae and 2 solenidia.

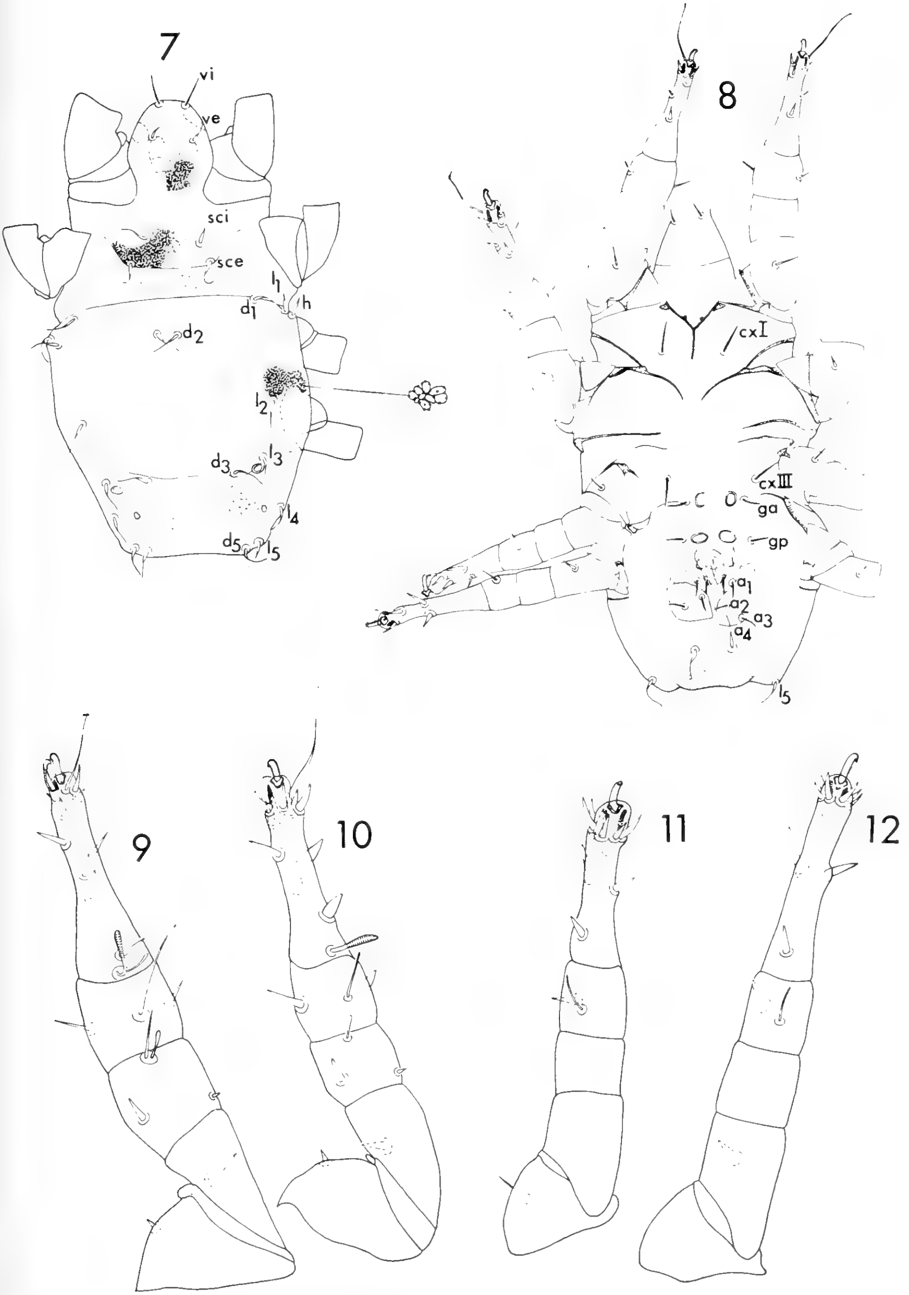
Tritonymph
Figs. 13–18

Idiosoma and gnathosoma of 10 specimens average 223 (121–294) μ long and 133 (70–185) μ wide. The rather large variation in measurements probably reflects the presence of both male- and female-forming tritonymphs.

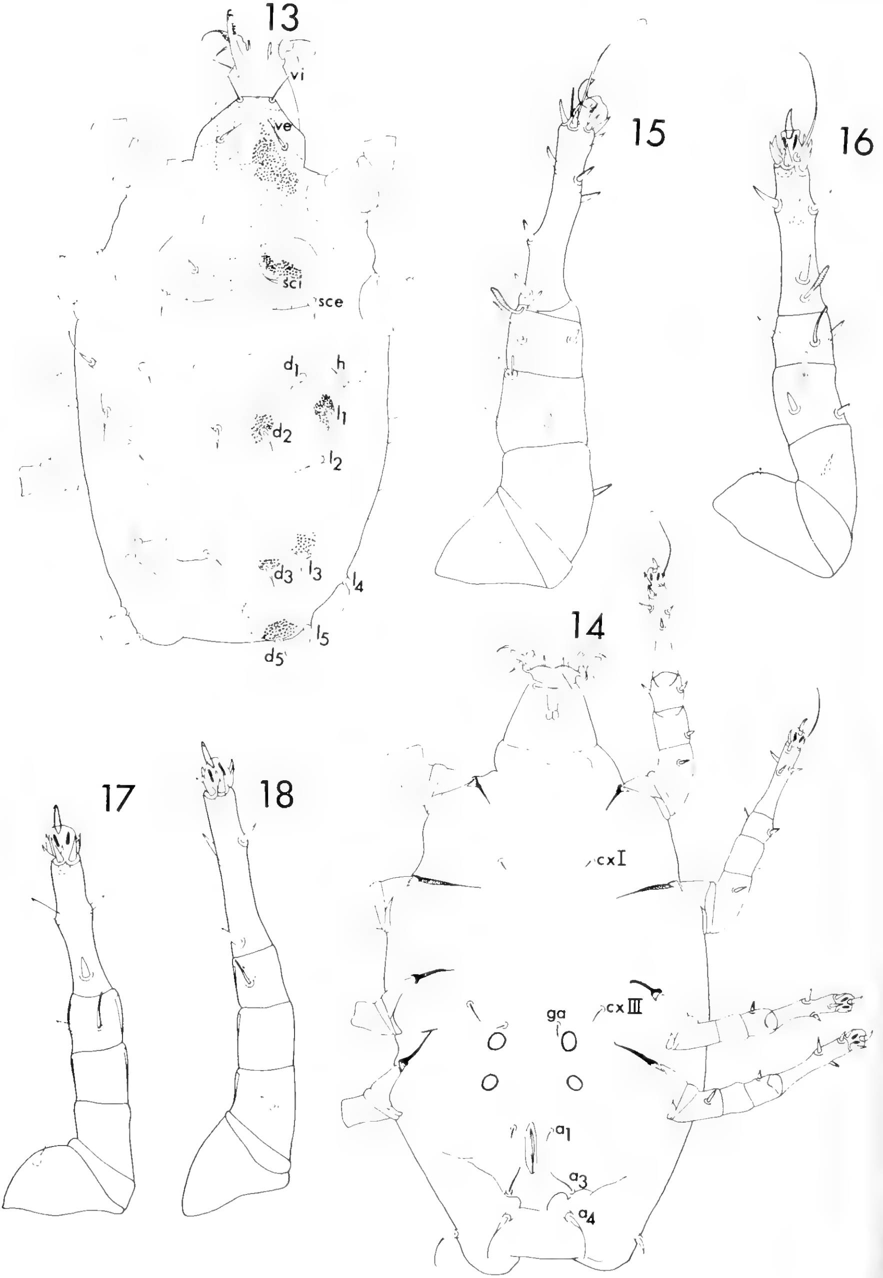
Dorsum (Fig. 13).—Anterior of propodosoma and platelet (pl) connected, both sculptured. Type, arrangement and relative size of dorsal setae similar to those of female; setae d_4 missing; dorsal setae located on distinct bosses. Dorsal pores missing.

Venter (Fig. 14).—Two pairs of sclerotic ringlike structures at level of coxae IV. Setae ga above anterior ringlike structure. Chaetotaxy similar to that of female, but gp lacking. No sexual structures.

Legs (Figs. 15–18).—Chaetotaxy and solenidiotaxy as in female.



Figs. 7–12. *Histiostoma heinemanni*, male. 7. Dorsum; 8. Venter; 9–12. Respectively, legs I–IV.



Figs. 13–18. *Histiostoma heinemanni*, tritonymph. 13. Dorsum; 14. Venter; 15–18. Respectively, legs I–IV.

Hypopus
Figs. 19–24

Idiosoma of 10 specimens averages 81 (103–217) μ long and 138 (74–160) μ wide.

Gnathosoma (Fig. 20).—Elongate; ratio correlation of length; width is 1:4; 1 pair of flagellum longer than gnathosoma; anterolateral pair of short setae present.

Dorsum (Fig. 19).—Propodosoma broad; anterior of propodosoma with interrupted groove (as figured); setae vi in front of ve. Transverse groove complete, posterior with broken-line area. Hysterosoma oval shaped; posterior broadly rounded; surface smooth. Dorsal setae short, setiform, subequal in length.

Venter (Fig. 20).—Epimera I fused medially; sternum free posteriorly, epimera II connected with epimera III by a fine sclerotized extension from latter; epimera III free; posterior and anterior of posterior sternum free. Suckers on epimera II on coxal plate III, and laterad on genital area. Setae sh, genital setae, and "anal setae" small and setiform. Anal opening located about ⅔ the length of the suctorial plate from caudal end.

Chaetotaxy of legs (Figs. 21–24).—Tarsi, 8-9; tibiae, 2-2; tibiotarsi, 7-7; genua, 3-2-2; femora, 1-1-0-1; trochanters 0-0-1-0. Solenidiotaxy: Tarsi, 3–1; tibae, 0-1; genua, 0-1-0.

Protonymph
Figs. 25–30

Average length of idiosoma of 7 specimens: 221 (160–262) μ long and 124 (108–134) μ wide; cuticle punctate.

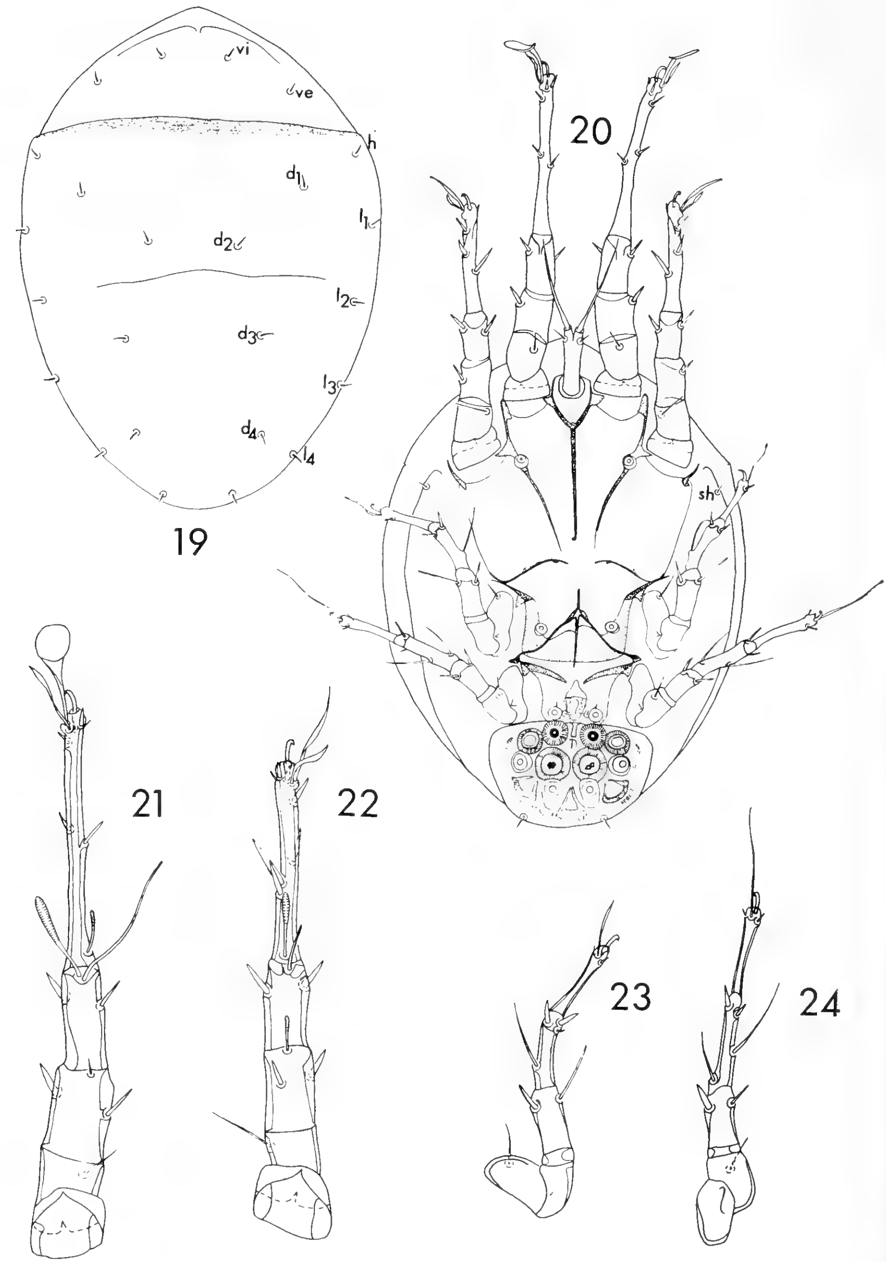
Dorsum (Fig. 25).—Anterior of propodosoma sculptured; platelet (pl) bordered by setae sci and sce. Dorsal chaetotaxy as in female, but setae relatively smaller.

Venter (Fig. 26).—One pair of sclerotic ringlike structures at level of coxae IV. No sexual structures present. Chaetotaxy as in female, but setae ga and gp lacking.

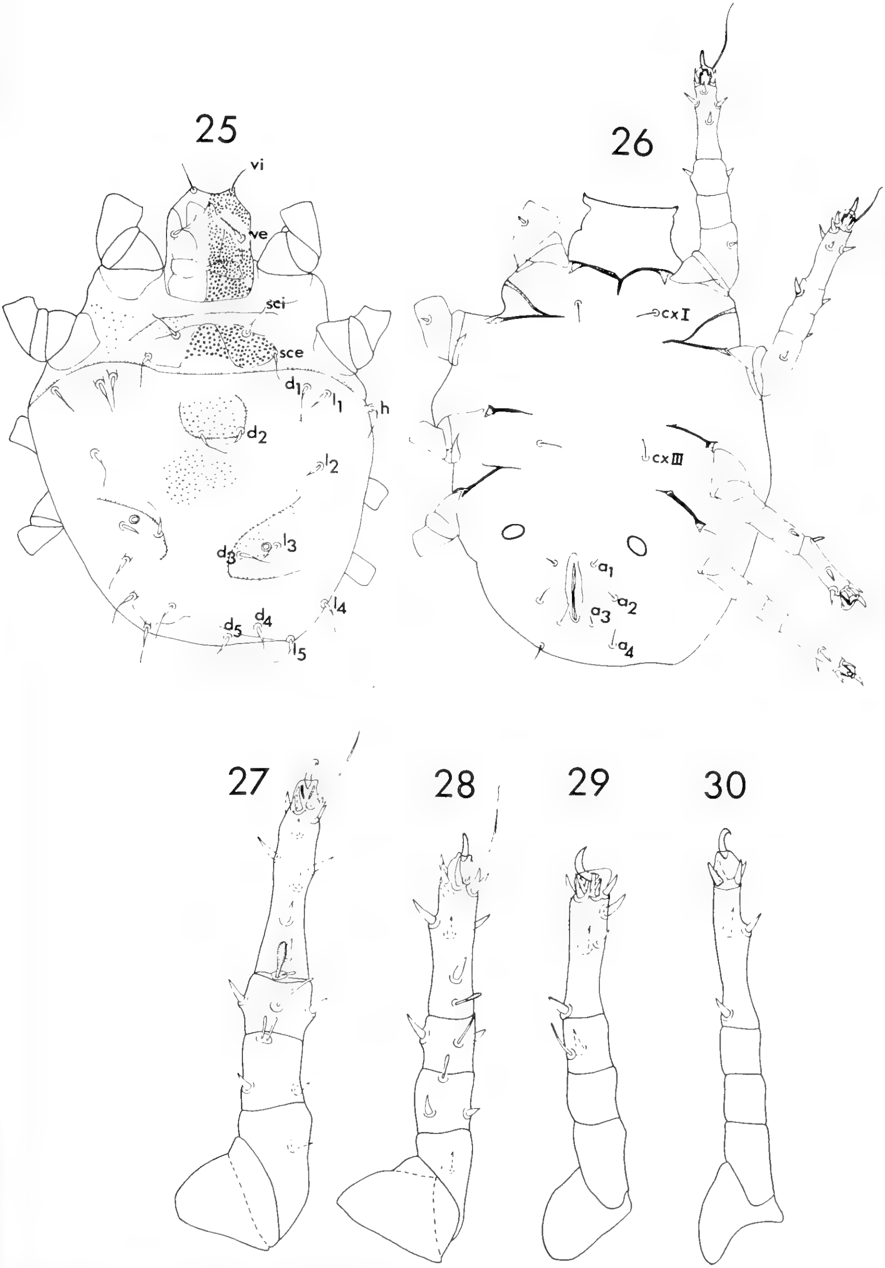
Leg (Figs. 27–30).—Legs differ from those of female in lack of spines on trochanters I–III; leg IV differs also in absence of spine and famulus on tibia and absence of 3 spines around pretarsus. Chaetotaxy: Tarsi, 13-12-10-7; tibiae, 2-2-1-0; genua, 2-2-0-0; femora, 1-1-0-0; trochanters 0-0-0-0. Solenidiotaxy: Tarsi, 2-1-0-0; tibiae, 1-1-1-0; genua, 2-1-0-0.

Larva
Figs. 31–35

Idiosoma of 8 specimens avergaes 160 (109–185) μ long and 93 (76–109) μ wide.



Figs. 19–24. *Histiostoma heinemanni*, hypopus. 19. Dorsum; 20. Venter; 21–24. Respectively, legs I–IV.



Figs. 25–30. *Histiostoma heinemanni*, protonymph. 25. Dorsum; 26. Venter; 27–30. Respectively, legs I–IV.

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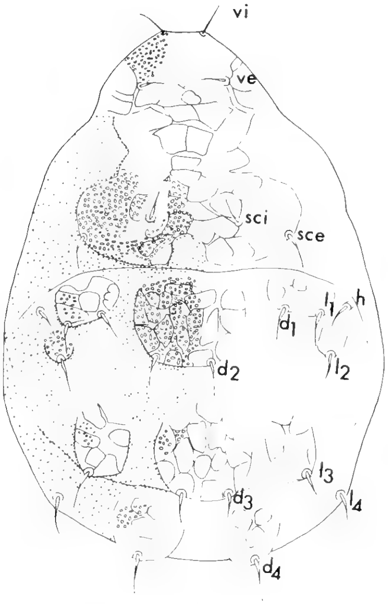

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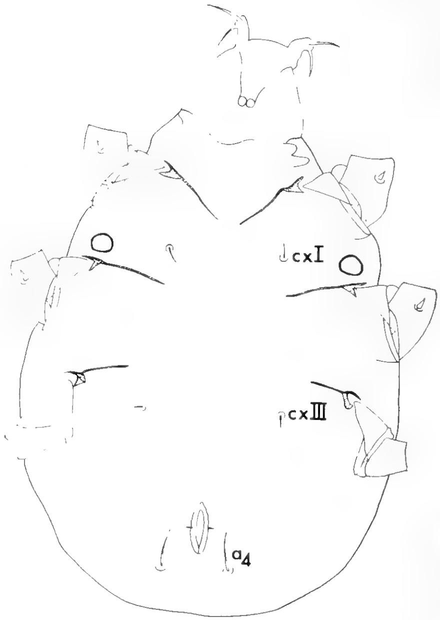

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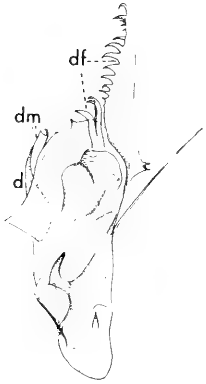

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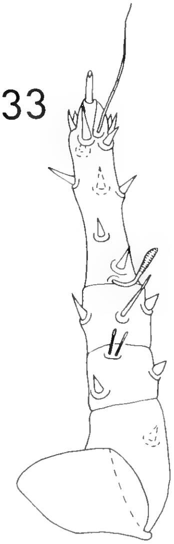

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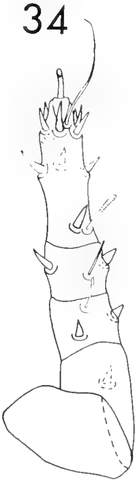

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Figs. 31–35. *Histiostoma heinemanni*, larva. 31. Dorsum; 32. Venter; 33–35. Respectively, legs I–III. Figs. 36–37. *Histiostoma heinemanni*, gnathosoma of all stages.

Dorsum (Fig. 31).—Anterior of propodosoma sculptured and contiguous with sculptured platelet (pl). Dorsal setae on distinct sculptured bosses. Chaetotaxy as in female, but d_5 and l_5 absent.

Venter (Fig. 32).—One pair of chitinous ringlike structures anterior to coxae II. Setae cx I, cx III and a_4 present; setae a_1–a_3, ga and gp absent.

Legs (Figs. 33–35).—Leg I differs from that of female in absence of spine on trochanter, 1 solenidion on tarsus, and famulus on pretarsus; legs II and III differ in absence of spine on trochanter. Chaetotaxy: Tarsi, 13-12-10; tibiae, 2-2-1; genua, 2-2-0; femora, 1-1-0; trochanters, 0-0-0. Solenidiotaxy: Tarsi, 1-1-0; tibiae, 1-1-1; genua, 2-1-0.

Deposition of type material.—Holotype: Female, USNM No. 3836 from mushroom compost from the mushroom farm of R. Dowell, Toughkenamon, Pennsylvania, 8 August 1976, by A. Hill and K. L. Deahl. Paratypes were collected from horse manure, first-stage mushroom and mushroom compost in Chester County, Pennsylvania as follows: R. Dowell, Toughkenamon, 8 August 1976; P. Yeatman, Avondale, 13 October 1976; Keystone Company, Coatesville, 31 August 1976; G. Guizetti, Toughkenamon, 15 September 1976; C. Nigro, Cochranville, 8 August 1976. Hypopi were also collected from phorid flies caught in the mushroom houses. We also obtained several stages from the Experimental Mushroom House, BARC-West, USDA, Beltsville, Maryland. Paratypes are deposited with the following: U.S. National Museum of Natural History, Washington, D.C.; Institute de Medecine Tropicale, Antwerp, Belgium; Ryksmuseum van Natuurlijke Historie, Leiden, Netherlands; Dr. R. L. Heinemann, Longwood College, Farmville, Virginia; Acarology Laboratory, Ohio State University, Columbus, Ohio; Catholic University, Nijmegen, Netherlands; Hungarian Natural History Museum, Budapest, Hungary.

Etymology.—This species is named for Dr. R. L. Heinemann, Longwood College, Farmville, Virginia.

Discussion

In the family Histiostomidae, the generic classification has been based on the hypopus stage. Differences between hypopi can be minute and older descriptions were sometimes incomplete, so identification has been difficult. Except for the absence of the broken-line area posterior to the transverse groove and contiguity of the epimera IV, the hypopus of *H. feroniarum* described by Scheucher (1957) is identical with hypopus of *H. heinemanni* in that the former has an extra pair of dorsal setae and one sensory seta on tarsus I instead of two.

A significant difference between the two species is the presence of a platelet on the dorsal propodosoma of adults and developmental stages of the species only, this platelet has not been described previously. The form of the platelet is probably growth dependent because the platelet is sometimes medially split into two or nearly so. In some specimens (Fig. 13) the platelet is connected with the anterior sculptured part of the propodosoma, but usually it is separate and bordered by setae sci and sce. Compatible with previous descriptions are dorsal bosses, obvious in the development stages but also readily visible in the adults.

For *H. feroniarum*, Scheucher (1957) shows 11 pairs of dorsal setae and 3 pairs of anal setae in the female and the male; Hughes and Jackson (1958) show 12 pairs of dorsal setae in the female and 11 in the male, and 3 pairs of anal setae for both. *Histiostoma heinemanni* has 11 pairs of dorsal and 4 pairs of anal setae in the female and 10 pairs of dorsal and 4 pairs of anal setae in the male. Also, Scheucher (1957) figures only 1 sensory seta on tarsus I of the female of *H. feroniarum*, whereas 2 sensory setae are present on tarsus I of the female of *H. feroniarum*, as described by Hughes and Jackson (1958), and on tarsus I of the female of *H. heinemanni*, as described here. Furthermore, Scheucher (1957) describes a second claw lacking in other descriptions on tarsi I and II of the male of *H. feroniarum.* The life cycle of *H. heinemanni* seems very similar to that described for *H. feroniarum* except that we found both homeomorphic and heteromorphic males in the culture, whereas Scheucher (1957) found only heteromorphic males of *H. feroniarum.* The difference could be inherent in the species or could be a result of environmental conditions. In the mushroom houses we frequently saw many *H. heinemanni* on mushrooms that were decaying as a result of infection with *Verticillium malthousei* Ware, *Pseudomonas tolaasii* Paine (Deahl, unpublished) and various secondary saprophytic invaders. *Histiostoma heinemanni* apparently does not feed on the mushroom tissue but is probably attracted by the presence of the microorganisms. However, by feeding on the microorganisms, this mite may be important in the spread of diseases. Only one species, *Histiostoma gracilipes* (Banks) is known to injure mushrooms by feeding on the spawn (Compton, 1933).

Acknowledgments

We thank Edward W. Baker, Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, USDA, and R. L. Heinemann, Longwood College, Farmville, Virginia, for their help with writing this paper.

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PROC. ENTOMOL. SOC. WASH.
80(3), 1978, pp. 330–334

TWO NEW SPECIES OF *TARSONEMUS* (ACARI: TARSONEMIDAE) ASSOCIATED WITH COMMERCIAL MUSHROOM PRODUCTION

Aagje Hill and Kenneth L. Deahl

Abstract.—Females of two new species of Tarsonemidae, *Tarsonemus mercedesae* and *T. lukoschusi*, associated with commercial mushroom production in Pennsylvania are described and figured.

A survey of mites associated with commercial mushroom production was made near Kennett Square, Pennsylvania. Two new species in the Tarsonemidae were found. The specimens described in this paper were collected from first-stage mushroom compost and horse manure outside mushroom houses. The terminology of Lindquist (1969) is used for the idiosomal and gnathosomal structures. The terminology of Suski (1966) is used for the chaetotaxy and solenidiotaxy of the legs. This work was done in collaboration with the Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland 20705.

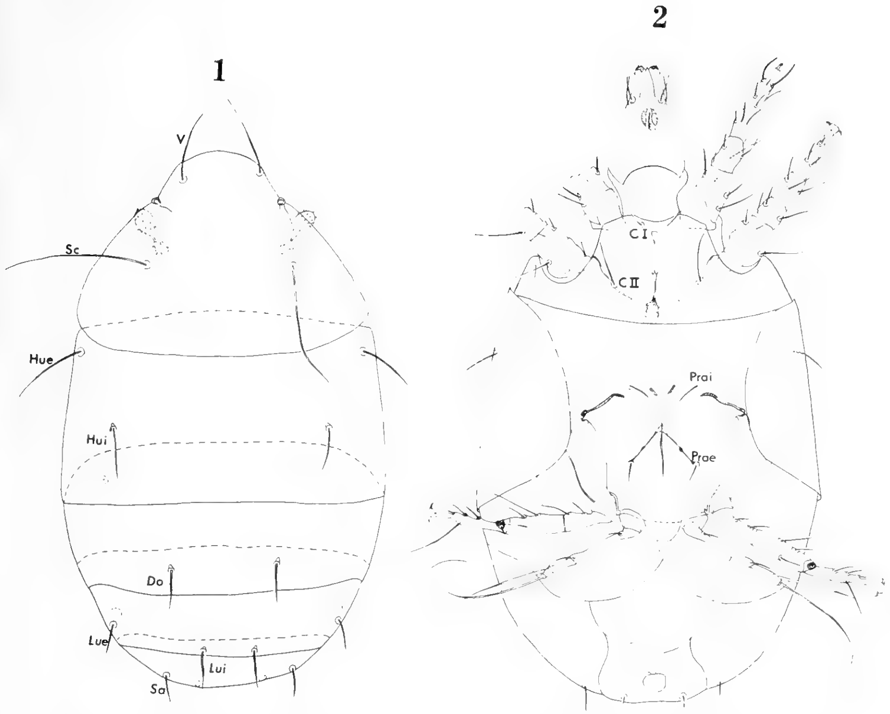
Tarsonemus mercedesae Hill and Deahl, new species
Figs. 1–4

Tarsonemus mercedesae can be distinguished from other species in the genus by the presence of a dark spot on the membrane between genu and tibiotarsus III. Only the female is known.

Gnathosoma (Fig. 2).—Pharynx short and slender, with a pair of distinct glandular structures posteriorly. Ventral and dorsal marginal setae subequal in length.

Dorsum (Fig. 1).—Body oval, broadest at metapodosomal area. Propodosomal shield subtriangular and partially covering gnathosoma. Shield somewhat less than 1.5× as broad posteriorly as it is long medially. Sensilla spherical, finely spiculate and mostly covered by the propodosoma. Vertical setae (V) longer than distance between bases; scapular setae (Sc) almost 2× as long as V. Marginal setae on tergum I subequal in length to V and longer than other hysterosomal setae; median setae on terga II and III equal in length, ½ as long as marginal setae on tergum I and stronger than other dorsal setae; marginal setae on terga III and IV subequal in length and shorter and more slender than other dorsal setae. Pores on terga I, II and IV.

Venter (Fig. 2).—Anteromedian apodeme interrupted between coxae I and II and not connected with apodemes II; apodemes II slightly curved; posterior portion of anteromedian apodeme trifurcate anteriorly, with



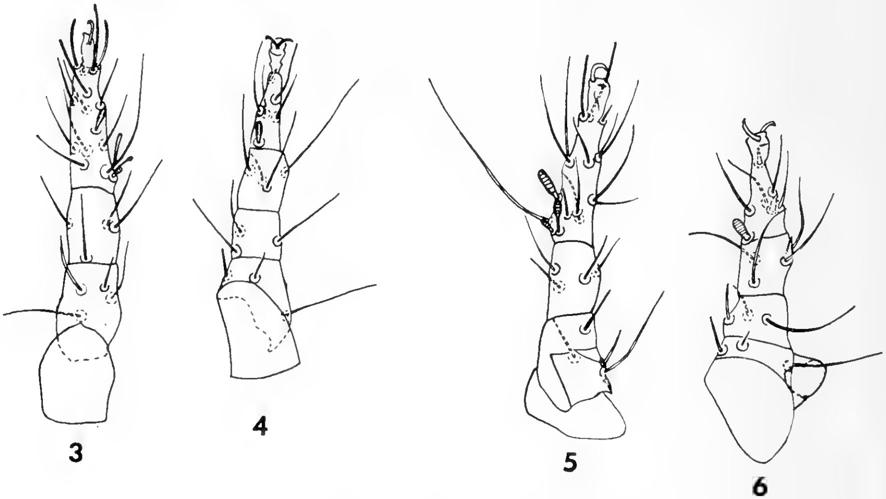
Figs. 1–2. *Tarsonemus mercedesae*, female. 1. Dorsal view; 2. Ventral view.

sclerotized area posteriorly. Coxal setae I less than ½ as long as II, which are relatively long. Transverse apodeme complete. Apodemes III extend medially to posterior of coxal setae III and laterally to anterior extremities of coxae III; medial parts of apodemes III curved posteriorly; apodemes IV slender and connected with posteromedian apodeme, with median nodule; posteromedian apodeme slender, complete, anterior bifurcate and not strongly sclerotized. Posteromedial lobe between coxae IV broader than long and distally rounded. Genital-anal plate distinct and with 1 pair of short, slender setae.

Chaetotaxy and solenidiotaxy of legs.—Leg I (Fig. 3): Femur, genu, tibiotarsus: 4-4-8 + 4 solenidia + 4 eupathidia. Leg II (Fig. 4): Femur, genu, tibia, tarsus: 3-3-4-5 + 1 solenidion. Leg III (Fig. 2): Femorogenu, tibia, tarsus: 2-3-4. Leg IV (Fig. 2): Femorogenu 2, tibiotarsus 2.

Measurements of type-material.—Holotype: Idiosoma plus gnathosoma 179 μ long; idiosoma 92 μ wide. Idiosoma of paratypes (3) averages 169 (163–173) μ long and 93 (85–101) μ wide.

Deposition of type-material.—Holotype: Female, USNM, No. 3761 from



Figs. 3–4. *Tarsonemus mercedesae*, female. 3. Leg I; 4. Leg II. Figs. 5–6. *Tarsonemus lukoschusi*, female. 5. Leg I; 6. Leg II.

first-stage mushroom compost, P. Yeatman, Avondale, Pennsylvania, 13 October 1976, by A. Hill and K. L. Deahl. Paratypes: Three from horse manure, Keystone Mushroom Company, Coatesville, Pennsylvania 31 August 1976, by A. Hill, in U.S. National Museum of Natural History.

Etymology.—This species is named for Dr. Mercedes Delfinado, New York State Museum, Albany, New York.

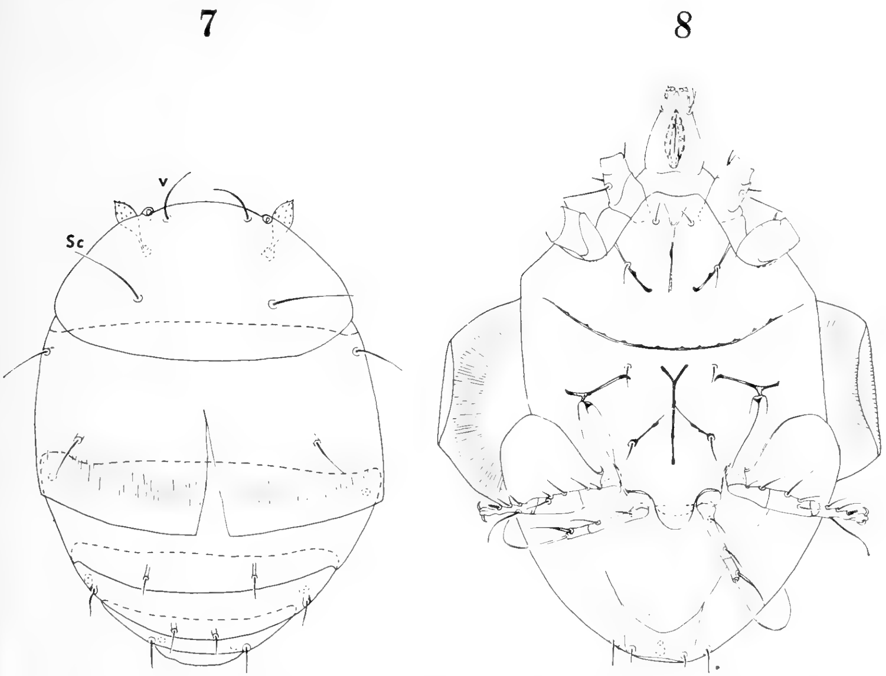
Tarsonemus lukoschusi Hill and Deahl, new species

Figs. 5–8

Tarsonemus lukoschusi can be distinguished from other species in the genus by the presence of broadly lanceolate sensilla, previously found only in some species of *Steneotarsonemus*, such as S. *phyllophorus* (Ewing) and S. *laticeps* (Halbert) (R. Smiley, personal communication). Only the female of is known.

Dorsum (Fig. 7).—Body oval. Propodosomal shield sub-triangular, not covering gnathosoma. Vertical setae (V) shorter than distance between bases. Scapular setae (Sc) fine and ⅓ longer than V. Sensilla broadly lanceolate with conspicuous spicules and partially covered by propodosomal shield. Dorsal hysterosomal setae simple. Setae on tergum I short and subequal in length; marginal setae on terga III and IV subequal in length. Three pairs of glandular openings on dorsum.

Venter (Fig. 8).—Apodemes I fused, Y-like, and connected with anteromedian apodeme; apodemes II not connected with anteromedian apodeme



Figs. 7–8. *Tarsonemus lukoschusi*, female. 7. Dorsal view; 8. Ventral view.

and each with a medial and a distal nodule. Anteromedian apodeme weakened between apodemes I and II; posteriorly with diffuse sclerotization. Transverse apodeme is complete and irregular (as figured). Apodemes III extend medially to posterior of coxal setae III and laterally beyond coxal III; posteromedian apodeme bifurcate anteriorly; apodemes IV finer than III, with median nodule; coxal setae I, II, and III finer and shorter than IV. Posteromedial lobe between coxae IV about as broad as long. Genital-anal plate distinct and with 1 pair of short slender setae.

Chaetotaxy and solenidiotaxy of legs.—Leg I (Fig. 5): Femur, genu, tibiotarsus: 4-4-11 + 3 solenidia + 3 eupathidia. Leg II (Fig. 6): Femur, genu, tibia, tarsus: 3-3-4-6 + 1 solenidion. Leg III (Fig. 8): Femorogenu, tibia, tarsus; 1-3-4. Leg IV (Fig. 8): Femorogenu 2, tibiotarsus 2. Femur II with large flange. On tibia II of holotype, protuberance appears spine-like; it appears as a protrusion in paratypes.

Measurements of type-material.—Holotype: Idiosoma plus gnathosoma 182 μ long and 101 μ wide. Idiosoma of paratypes (6) averages 163 (142–196) μ long and 92 (81–106) μ wide.

Deposition of type-material.—Holotype: Female, USNM No. 3760 from first-stage mushroom compost, P. Yeatman, Avondale, Pennsylvania, 13

October 1976, by A. Hill and K. L. Deahl. Paratypes: Two are in Acarology Laboratory, Ohio State University, Columbus, Ohio; 2 in Biosystematics Research Institute, Ottawa, Ontario, Canada; and 4 in U.S. National Museum of Natural History, Washington, D.C.

Etymology.—This species is named for Dr. F. S. Lukoschus, Catholic University, Nijmegen, Netherlands.

Acknowledgments

We thank Edward W. Baker and Robert L. Smiley, Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, USDA, and Mercedes D. Delfinado, New York State Museum and New York State Education Department, Albany, New York, for their help with writing this paper.

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Vegetable Laboratory, PGGI, BARC-West, USDA, Beltsville, Maryland 20705 (A. Hill, former research assistant and graduate student from Botany Department, Catholic University, Nijmegen, Netherlands).

PROC. ENTOMOL. SOC. WASH.
80(3), 1978, pp. 335–343

A NEW SPECIES OF *PSEUDOPYGMEPHORUS* (ACARI: PYGMEPHORIDAE) ASSOCIATED WITH COMMERCIAL MUSHROOM PRODUCTION

Aagje Hill and Kenneth L. Deahl

Abstract.—Both sexes of a new species of Pygmephoridae, *Pseudopygmephorus smileyi*, from horse manure around commercial mushroom production houses in Pennsylvania are described and figured.

Mites associated with commercial mushroom production were studied at the Beltsville Agricultural Research Center in 1976. Most of the mites were collected from compost and horse manure around and in the mushroom houses near Kennett Square, Pennsylvania. This work was done in collaboration with the Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland 20705.

Several species of mites belonging to the family Pygmephoridae and Tarsonemidae were found. Among them were males and females of an undescribed species of *Pseudopygmephorus*, and these are described here. As far as we know, this is the third species in this genus for which males are known. The terminologies of Mahunka (1973) and Norton and Ide (1974) are used for the idiosomal structures, leg chaetotaxy and solenidiotaxy.

Pseudopygmephorus smileyi Hill and Deahl, new species

The female of this species resembles the female of *Pseudopygmephorus sellnicki* (Krczal, 1959) in having similarly curved dorsal terga. It can be separated from the latter species by the absence of strong spinelike setae on tarsi II and III. Smiley (1978) describes the male of *P. sellnicki*. The male of *P. smileyi* differs from the male of *P. sellnicki* in having slender setae rather than strong spines on tarsi II and III.

Female
Figs. 1–6

Gnathosoma (Fig. 1).—Slightly elongate with 2 pairs of simple dorsal setae, anteromedial pair longest. Palpus with 1 segment, dorsally with 2 pairs of simple setae, ventrally with 1 small solenidion and a larger sucking-like apparatus.

Dorsum (Fig. 1).—Propodosoma convex anteriorly, with concave margins, rather small in comparison to body. Exobothridial setae (exo) longer than distance between bases. Interbothridial setae (in) very small, without spicules. Rostral setae lacking. Setae c_2 on tergum I longer than exo setae;

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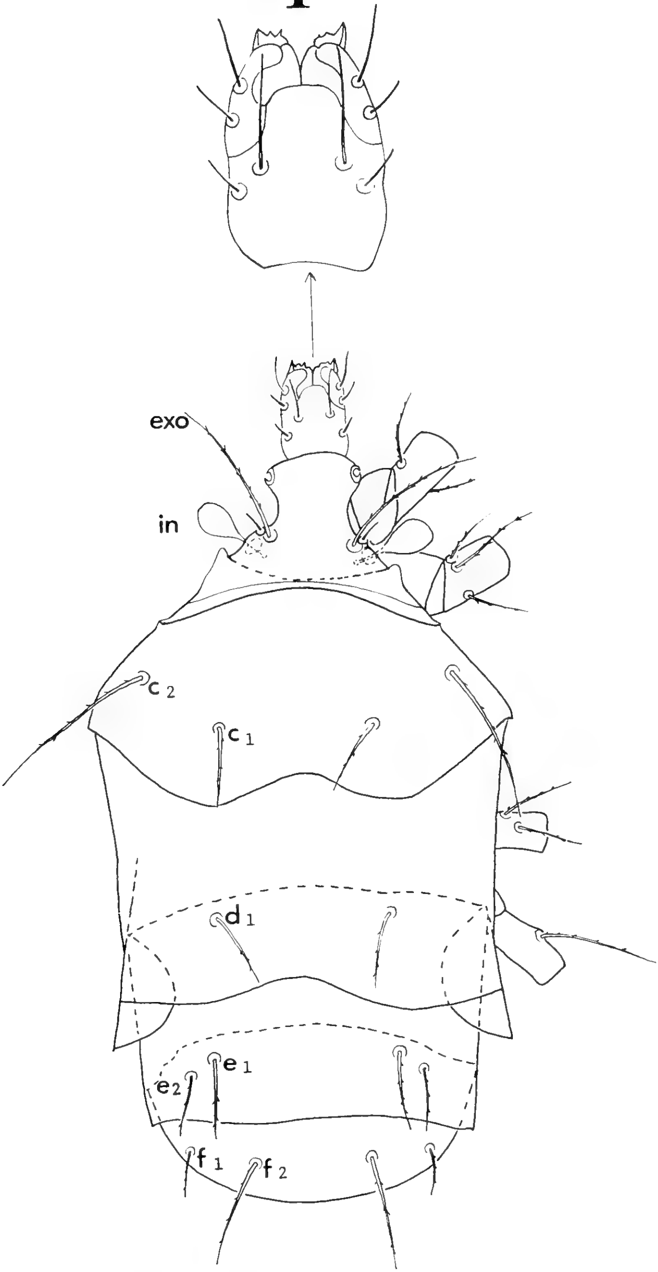

Fig. 1. *Pseudopygmephorus smileyi*, female with gnathosoma enlarged, dorsal view.

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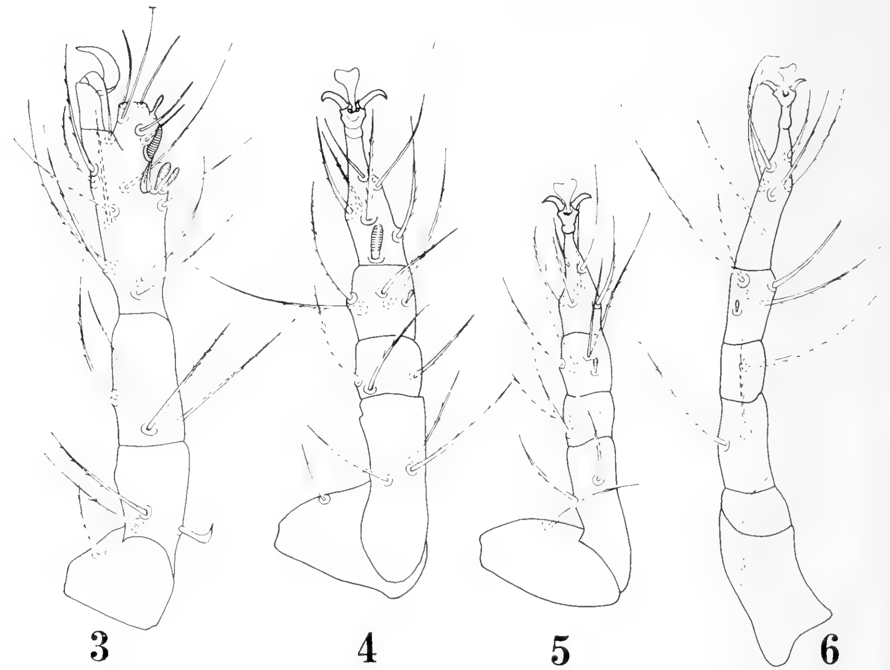
Fig. 2. *Pseudopygmephorus smileyi*, female with gnathosoma enlarged, ventral view.



Figs. 3–6. *Pseudopygmephorus smileyi*, legs I–IV of female.

setae c_1 on tergum I, d_1 on tergum II, and e_1 on tergum III about equal and ½ the length of c_2; setae f_1 somewhat longer than ½ the length of setae c_1 and f_2 longer than c_1. All setae spiculate, unless otherwise stated.

Venter (Fig. 2).—Apodemes II longer than I, both connecting with anteromedian apodeme; anteromedian apodeme connecting with transverse apodeme; posteromedian apodeme connecting with apodemes III and IV; 5th apodeme lacking. Propodosomal setae 1a spiculate, somewhat shorter than distance between their bases; setae 1b bifurcate and spiculate; setae 2a spiculate and longer than 1b; setae 2a twice as long as 2b. Hysterosomal setae 3a and 3c not as long as 3b; setae 3b thicker than 3a and 3c; setae 4a and 4c subequal in length; setae 4b longer than other hysterosomal setae. Caudal setae 3h longest and spiculate; setae 1h and 2h short and slender. All hysterosomal setae smooth, unless otherwise stated.

Chaetotaxy and solenidiotaxy of legs.—Leg I (Fig. 3): Femur, genu, tibiotarsus: 3-4-12 + 4 solenidia + 4 eupathidia. Leg II (Fig. 4): Femur, genu, tibia, tarsus: 3-3-4 + 1 solenidion, –6 + 1 solenidion. Leg III (Fig. 5): Femur, genu, tibia, tarsus: 2-2-4 + 1 solenidion, –6. Leg IV (Fig. 6): Femur, genu, tibia, tarsus: 2-1-4 + 1 solenidion, –6.

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Fig. 7. *Pseudopygmephorus smileyi*, male with gnathosoma enlarged, dorsal view.

Measurements of type-material.—Holotype: Idiosoma plus gnathosoma 275 μ long and 126 μ wide. Idiosoma of female paratypes (10) averages 272 (225–320) μ long and 136 (167–113) μ wide.

Male
Figs. 7–12

The males vary in body size and in the size of the leg setae. Venter and dorsum are drawn from different specimens.

Gnathosoma (Fig. 7).—Small, elongate, with 2 pairs of simple dorsal setae, 1 pair of solenidia, and 1 pair of simple ventral setae; anteriorly with oblong sucking-like apparatus. Palpi absent, chelicerae not visible.

Dorsum (Fig. 7).—Propodosomal shield rounded anteriorly; wider posteriorly than long; medially with 3 pairs of spiculate setae. Prodorsal setae pd$_1$ and pd$_2$, ¼ the length of pd$_3$; setae pd$_3$ more than 2× as long as pd$_1$ and pd$_2$ combined. Hysterosoma with 3 pairs of setae; c$_1$ short; c$_2$ more than 2× as long as c$_1$; d ½ the length of c$_2$. All hysterosomal setae spiculate. Opisthosomal setae e$_1$ and e$_2$ spiculate; e$_2$ located anteriorly. Solenidia and microsetae (ms) present on sculptured genital area.

Venter (Fig. 8).—Apodemes I short and connecting with anteromedian apodeme; apodemes II not connected with anteromedian apodeme; anteromedian apodeme connecting with transverse apodeme; posteromedian apodeme connecting with apodemes IV and V; apodemes III not connecting medially. Propodosomal setae 1a smooth and longer than weakly spiculate setae 1b. Coxal setae 2a longer and stronger than 2 b; both smooth. Setae 2a and 1a subequal in length; coxal setae 3a and 3c subequal in thickness and length; setae 3b longer than 3a and 3b; coxal setae 4a and 4c similar to 3a and 3c; setae 4b longer than 4a and 4c. Aedeagus (aed) as figured.

Chaetotaxy and solenidiotaxy of legs.—Leg I (Fig. 9): Femur (not figured), genu, tibia, tarsus: 3-4-6 + 2 solenidia, –9 + 2 solenidia + 4 eupathidia. Leg II (Fig. 10): Femur (not figured), genu, tibia, tarsus: 3-3-4 + 1 solenidion, –7 + 1 solenidion. Leg III (Fig. 11): Femur (not figured), genu, tibia, tarsus: 1-2-4 + 1 solenidion, –7. Leg IV (Fig. 12): Femur, genu, tibia, tarsus: 1-1-3 + 2 solenidia, –4.

Measurements of type-material.—Average of paratypes (5): length: 222 (184–242) μ; width 108 (74–127) μ.

Deposition of type-material.—Holotype: Female, USNM No. 3759 from horse manure, Keystone Mushroom Company, Coatesville, Pennsylvania, 31 August 1976, A. Hill and K. L. Deahl. Paratypes: Five ♂ and 18♀ in U.S. National Museum of Natural History, Washington, D.C.; 1♀ at Univer-

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Fig. 8. *Pseudopygmephorus smileyi*, male, ventral view.

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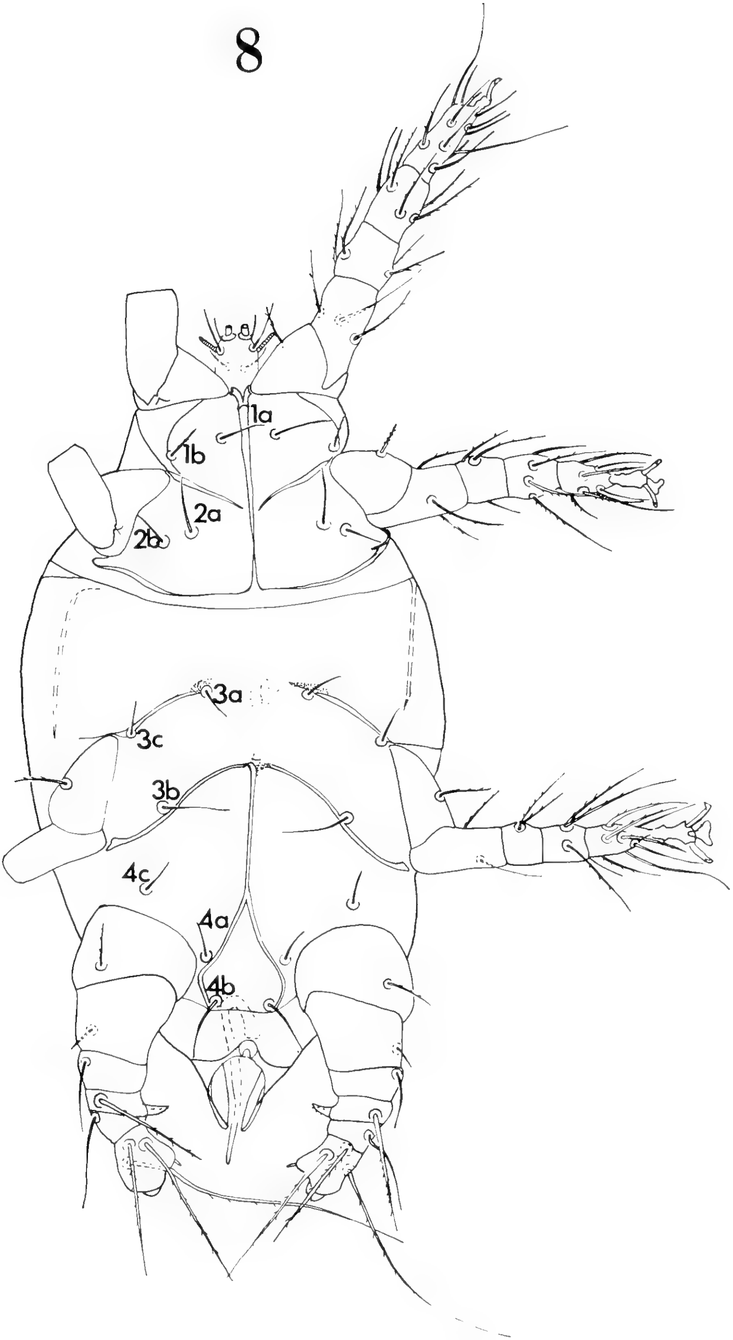

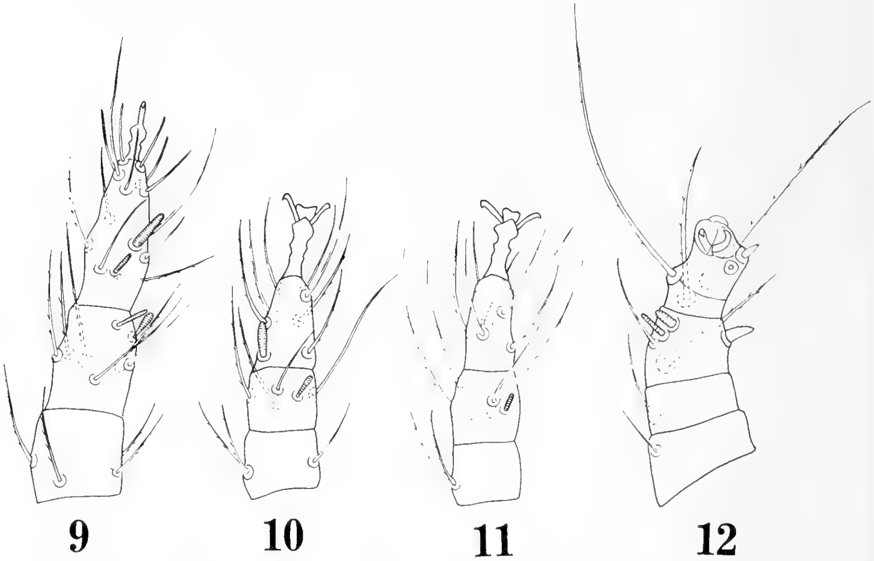

Figs. 9–12. *Pseudopygmephorus smileyi*, legs I–IV of male (femora not figured).

sity of Alabama, Tuscaloosa, Alabama; 1♀ in Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands; 1♀ in Acarology Laboratory, Ohio State University, Columbus, Ohio; 1♀ at Catholic University, Nijmegen, Netherlands; 1♀ in Hungarian Natural History Museum, Budapest, Hungary; 1♀ with U.S. Forest Service, Pineville, Louisiana; 1♀ in Zoologisches Institut and Zoologisches Museum, Universitat Hamburg, Hamburg, Germany; paratypes with the same data as holotype.

Etymology.— This species is named for Mr. Robert L. Smiley, Systematic Entomology Laboratory, IIBIII, USDA, Beltsville, Maryland.

Acknowledgments

We thank Edward W. Baker and Robert L. Smiley, Systematic Entomology Laboratory, IIBIII, Sci., USDA, for their help with writing this paper.

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Vegetable Laboratory, PGGI, BARC-West, USDA, Beltsville, Maryland 20705 (A. Hill, former research assistant and graduate student from Botany Department, Catholic University, Nijmegen, Netherlands).

NOTE

A NEW NAME FOR *COLPOCEPHALUM ABBOTTI* PRICE (MALLOPHAGA: MENOPONIDAE)

Price (1976. Syst. Entomol. 1:63) described *Colpocephalum abbotti*, and based the specific name on that of the ibis type-host, *Threskiornis aethiopica abbotti* (Ridgway).

Unfortunately, Kellogg (1899. Occas. Pap. Calif. Acad. Sci. 6:36) had previously described *Colpocephalum abbotti* for a louse taken from a gull, *Larus* sp. I had overlooked this earlier use of *C. abbotti* due to the fact that this name is now associated with the menoponid genus *Actornithophilus* Ferris and is further a junior synonym of *A. piceus* (Denny). A shortcoming in my card file failed to bring this to my attention. I thank Dr. R. C. Dalgleish, Rensselaerville, New York, for being more efficient and for pointing this homonymy out to me.

So, with *C. abbotti* Price a junior primary homonym of *C. abbotti* Kellogg, I hereby provide *Colpocephalum tandani* nomen novum to replace *C. abbotti* Price. This name is in recognition of the numerous excellent contributions of Dr. B. K. Tandan to Mallophaga taxonomy.

Roger D. Price, *Department of Entomology, Fisheries and Wildlife, University of Minnesota, St. Paul, Minnesota 55108.*

PROC. ENTOMOL. SOC. WASH.
80(3), 1978, pp. 344–359

TAXONOMIC NOTES ON *ZAGRAMMOSOMA*, A KEY TO THE NEARCTIC SPECIES AND DESCRIPTIONS OF NEW SPECIES FROM CALIFORNIA (HYMENOPTERA: EULOPHIDAE)

Gordon Gordh

Abstract.—*Zagrammosoma intermedium*, new species, and *Z. melinum*, new species, are described from California; *Z. intermedium* parasitizes *Lithocolletis nemoris*, and *Z. melinum* parasitizes *Bucculatrix* sp. The female of *Z. nigrolineatum* Crawford is described. *Zagrammosoma interlineatum* Girault is synonymized with *Z. multilineatum* (Ashmead) (NEW SYNONYMY); *Z. sanguineum* Girault is synonymized with *Z. nigrolineatum* Crawford (NEW SYNONYMY). A key to North American species of *Zagrammosoma* is provided; and distribution, host associations and taxonomic notes are given for each North American species.

The name *Zagrammosoma* was proposed by Ashmead (1904) as a replacement name for *Hippocephalus* Ashmead, 1888, which was preoccupied by *Hippocephalus* Swainson, 1839, in fishes. Catalogs of North American *Zagrammosoma* have summarized published taxonomic and biological information about the species (Muesebeck et al., 1951; Peck, 1963; Burks, in press). Presently eight species are included in *Zagrammosoma* from North America. Two new species are described in this paper, and two species are synonymized.

European and American workers differ in opinion regarding the generic position of *Zagrammosoma* and *Cirrospilus* Westwood. Bouček and Askew (1968) regard *Zagrammosoma* as a subgenus of *Cirrospilus*. This position was followed by Kerrich (1969). American workers consistently have maintained *Zagrammosoma* and *Cirrospilus* as generically distinct. Twenty species of *Cirrospilus* (*sensu* American authors) are recognized in North America. These will be considered in another paper.

The biologies of both genera are poorly studied but host relationships seem to be slightly different. Representatives of both genera are parasites of leafmining Lepidoptera and Diptera, but some species of *Cirrospilus* also parasitize leafmining Hymenoptera. *Cirrospilus* frequently acts as a hyperparasite of braconids and ichneumonids that attack leafminers, but only rarely have species of *Zagrammosoma* been found acting in a hyperparasitic role. When the biological associations of species in both genera are studied, more subtle differences may be found.

Zagrammosoma is abundant in the western states of North America and is especially well represented in California. *Cirrospilus* appears more common in the central and eastern states.

Some morphological characters may be of importance in separating these genera. There is a difference in the shape of the head: *Zagrammosoma* species have the vertex vaulted between the compound eyes, and the head is elongate; *Cirrospilus* species do not have the vertex vaulted between the compound eyes and the head shape is usually oval. Most specimens in both genera shrivel after death so this character is not always visible. Specimens of *Cirrospilus* have a well-developed median propodeal carina (except one undescribed species). Specimens of *Zagrammosoma* do not have a median propodeal carina, or it is weakly developed.

Generic concepts in the Eulophinae show that differences between genera are often slight and qualitative. If *Zagrammosoma* and *Cirrospilus* are considered congeneric, then a strong argument could be made for synonymizing *Microlycus* Thomson with *Necremnus* Thomson and *Hemiptarsenus* Westwood with *Notanisomorpha* Ashmead because the differences between these genera are qualitative and slight.

Thus it seems that we do not know enough about the biology, distribution and morphological variation of *Zagrammosoma*, *Cirrospilus* and related genera of Eulophinae. For the present it seems more appropriate to maintain them as generically distinct until they are better known.

Genus *Zagrammosoma* Ashmead

Hippocephalus Ashmead, 1888:App. VIII. Type species: *Hippocephalus multilineatus* Ashmead. Monotypic.

Zagrammosoma Ashmead, 1904:354, 393. Replacement name for *Hippocephalus* Ashmead, not *Hippocephalus* Swainson.)

Zagrammatosoma Schulz, 1906. Spolia Hym., pg. 142. Unjustified emend.

Atoposoma Masi, 1907. Bol. Lab. Zool. Gen. Agric., Portici. 1:276. *Atoposoma variegatum* Masi. Monotypic.

Key to North American *Zagrammosoma* Based on Females

1. Metasomal terga predominantly dark reddish, at least mesally, and with ornate color pattern (Figs. 1, 3, 7) 2

– Metasomal terga predominantly pale or without ornate color pattern (Figs. 4, 6) 6

2. Forewing hyaline; dorsal surface of adstigmal area densely setose (Fig. 16) *nigrolineatum* Crawford

– Forewing infuscated; dorsal surface of adstigmal area asetose (Figs. 10, 13, 15) 3

3. Forewing infuscation extending parallel to marginal vein from stigmal vein to basal cell (Figs. 11, 15); area posterior to junction of submarginal vein and marginal vein asetose; postmarginal vein pale, but as long as stigmal vein 4

– Forewing infuscation "U" shaped, extending from stigmal vein to junction of submarginal vein and marginal vein (Fig. 10); area posterior to juction of submarginal vein and marginal vein with coarse dark setae; postmarginal vein about ½ as long as stigmal vein 5

4. Dark brown mesosomal stripe broad (Fig. 4), as wide as distance between parallel longitudinal grooves on scutellum; notaulices pale; area posterior to junction of marginal vein and stigmal vein asetose (Fig. 15) *centrolineatum* Crawford

– Dark brown mesosomal stripe narrow (Fig. 5); notaulices dark brown; area posterior to junction of marginal vein and stigmal vein setose (Fig. 11) *intermedium*, new species

5. Metasoma entirely reddish brown; propodeal callus uniformly reddish brown; apex of hind femur pale, remainder reddish brown *mirum* Girault

– Metasoma dusky reddish brown ventrally with pale spots laterally; propodeal callus pale yellow, remainder of propodeum reddish brown; apex and basal ½ of hind femur pale, remainder dusky *flavolineatum* Crawford

6. Forewing with several infuscated spots or if infuscated spots faint, then junction of submarginal vein and marginal vein, marginal vein, and stigmal vein dusky or darkened; dorsal surface of adstigmal area asetose (Figs. 10–15) 7

– Forewing hyaline; dorsal surface of adstigmal area densely setose (Fig. 16) *nigrolineatum* Crawford

7. Anterior margin of mesoscutum with dark transverse stripe that is enlarged laterally forming a spot (sometimes concealed beneath posterior margin of pronotum) (Fig. 1) *americanum* Girault

– Anterior margin of mesoscutum without transverse stripe 8

8. Scutellum with longitudinal, medial stripe (Fig. 3); hind femur with dorsal stripe and apical spot; forewing blade with numerous setae (Fig. 12) *multilineatum* (Ashmead)

– Scutellum without longitudinal, medial stripe (Fig. 2); hind femur pale yellow, without stripe or spot; forewing blade with fewer setae (Fig. 14) *melinum*, new species

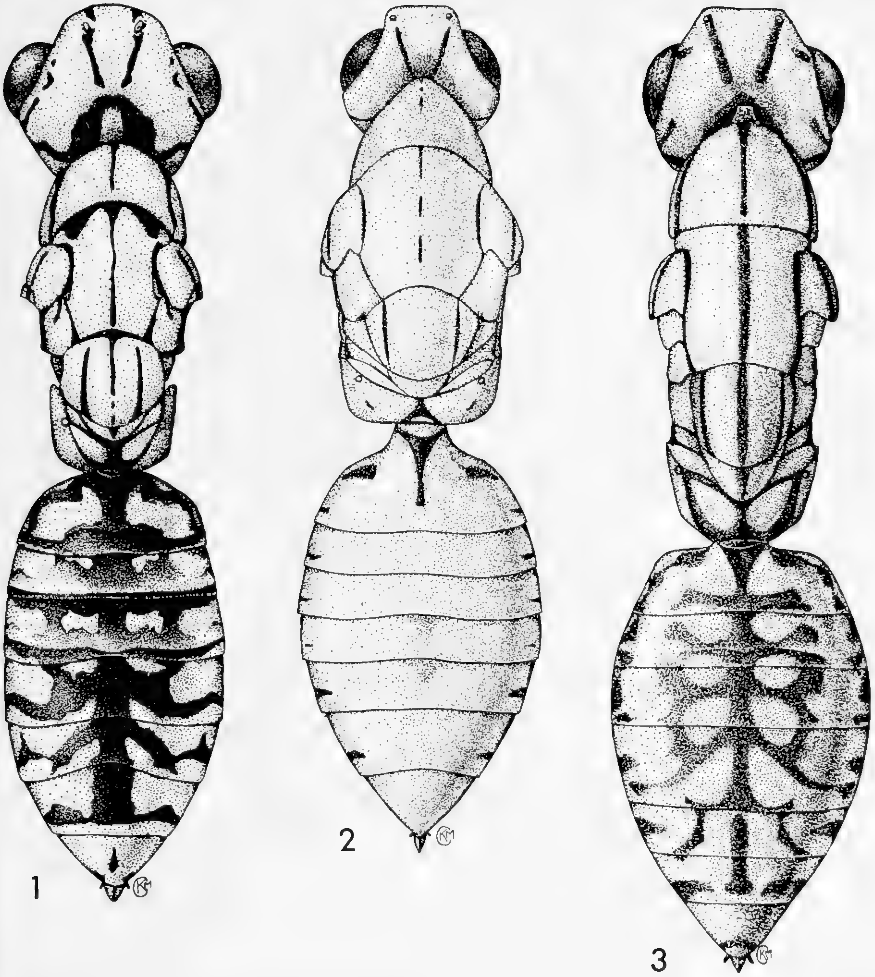
Zagrammosoma americanum Girault

Figs. 1, 13

Zagrammosoma americanum Girault, 1916:126–127.

Type-locality.—Boulder, Colorado.

Girault described this species from one female. Girault separated *Z. americanum* from *Z. multilineatum* based on the conspicuous, round, black dot near the apex of the hind femur. Some specimens of *Z. americanum*



Figs. 1–3. Dorsal view of *Zagrammosoma* species. 1. *Z. americanum*; 2. *Z. melinum*; 3. *Z. multilineatum*.

have this dot misshapen, and in others it is almost a stripe. The dorsal longitudinal stripe on the hind femur is also variable.

A more reliable character to distinguish these species is a transverse, dark stripe along the exposed margin of the mesoscutum (which also projects beneath the posterior margin of the pronotum). Laterally this stripe becomes two enlarged spots. This character is present only in *Z. americanum*.

The propodeal pigmentation of *Z. americanum* is variable and resembles

Z. multilineatum (the anterior and posterior margins are dark). In most specimens of both species the pigmentation on the meson extends posterolaterally and forms a "W." In some specimens it forms a median dot.

This species is abundant in California and is often found in association with pine. It has been reared from *Coleotechnites milleri* (Busck), *Coleophora laricella* (Hubner) and *Asphondylia* galls.

Zagrammosoma centrolineatum Crawford
Figs. 4, 15

Zagrammosoma centrolineatum Crawford, 1913:256.

Type-locality.—California.

Crawford described this species based on two females taken in Los Angeles County and one female taken in Sonoma, California. The specimen from Sonoma is conspecific with the specimens from Los Angeles. The paratype from Los Angeles is missing the metasoma.

Crawford's original description is accurate; supplementary illustrations of the habitus and forewing (Figs. 4, 15) will make recognition of this distinctive species relatively easy. Based on forewing characters this species is closely related to *Z. mirum*, *Z. flavolineatum* and *Z. intermedium.* It can be distinguished from these species based on characters given in the key.

Little information has been gathered on *Z. centrolineatum.* It has been recovered from Oregon, California and Utah. Hosts include *Caloptilia alnivorella* (Chambers), *Lithocolletes mediodorsella* Braun, *Lithocolletes* sp. on *Populus* spp. and *Quercus dumosa*, "leaf blotch mine" on *Q. wislizenii* and *Tischeria* sp. on *Q. dumosa englemanii.*

Zagrammosoma flavolineatum Crawford
Fig. 10

Zagrammosoma flavolineatum Crawford, 1913:255–256.

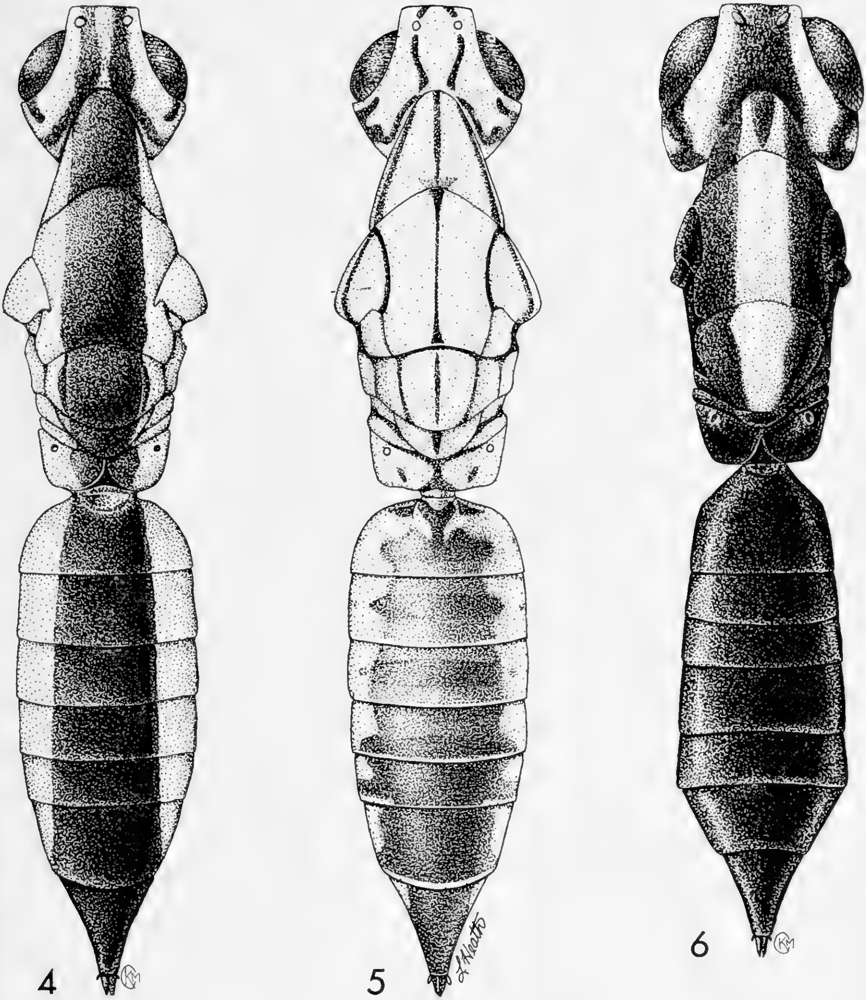
Type-locality.—Boulder Co., Colorado.

Crawford described this species from one female specimen, and the original description is accurate. For a discussion of this species see comments under *Z. mirum.*

Zagrammosoma intermedium Gordh, new species
Figs. 5, 11

Type-locality.—Palo Alto, California.

Female.—1.8 mm long. Body coloration as illustrated (Fig. 5); anterior aspect of head pale yellow except dark stripe extending from dorsomedial margin of compound eye to anterior ocellus; gonostylus dark brown; an-



Figs. 4–6. Dorsal view of *Zagrammosoma* species. 4. *Z. centrolineatum*; 5. *Z. intermedium*; 6. *Z. mirum*.

tennal pedicel with dusky spot on dorsal surface; funicular segments reddish brown, club dark brown. Forewing color pattern and setation as illustrated (Fig. 11). Legs pale yellow.

Head similar in shape and proportions to *Z. centrolineatum*.

Mesosoma with uniform alutaceous sculpture except on lateron of metanotum, pattern somewhat larger and not as deeply incised as in *Z. centrolineatum*. Pronotum with numerous scattered, short, dark setae and a row of larger setae along posterior margin; mesoscutum with 12 dark setae which become progressively larger posteriorly; scutellum with 2 pairs of large, dark setae with the posterior pair larger than the anterior pair. Propodeum with weak but complete median carina; callus with long, pale setae; spiracle round, about 1 diameter from anterior margin of propodeum.

Metasomal tergum with alutaceous sculpture, but pattern not as strongly incised as on mesosoma. Terga 1–3 with short, pale setae along posterolateral margin; terga 4–6 more densely setose and pattern complete transversely; tergum 7 uniformly setose along apical ½. Gonostylus densely setose.

Male.—Unknown.

Described from one female taken at Stanford University, Palo Alto, California during 1947 from parasitized *Cameraria nemoris* (Walsingham) by J. W. Tilden. Holotype deposited in the U.S. National Museum of Natural History (USNM Type 75663).

This species is similar to Z. *centrolineatum* but can be distinguished from that species on the forewing characters given in the key and by the width of the mesosomal stripe.

After the description of this species the head was inadvertently lost. I have decided to describe the species on the basis of an imperfect specimen because the host is known and the species has a distinctive habitus.

This species is the same as that referred to by Tilden (1949) in his short note on leafminer parasites.

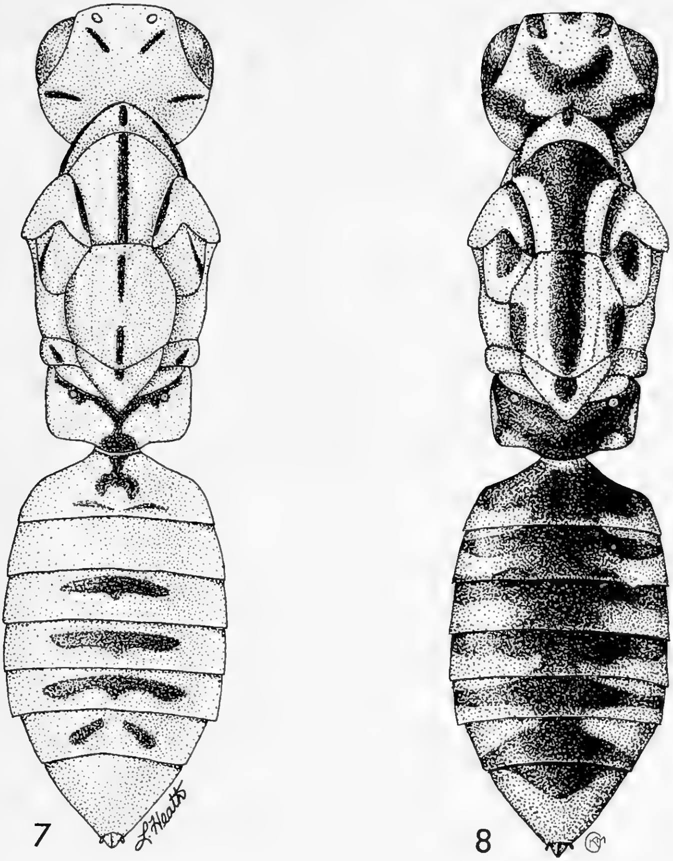
Etymology.—The specific name is a Latin adjective (*intermedius*) and means intermediate.

Zagrammosoma melinum Gordh, new species
Figs. 2, 9, 14

Type-locality.—Coalinga, California.

Female.—2.3 mm long. Body pale yellow except the following (Fig. 2); dark stripes under compound eye extending from medial margin to posterior ocellus; pronotum with 2 parallel, longitudinal, narrow stripes, 1 lateral and 1 dorsomesal; mesoscutum with lateral, longitudinal mesal stripe and a short, dark line on notaulices; scutellum with 2 short stripes halfway between median carina and spiracles; posteriomesal margin dark; basal gastral tergum with lateral spot; pygostylus brown; distal ½ of gonostylus dark brown. Antennal scape and pedicel with dark dorsal stripes (Fig. 9). Forewing hyaline except faint dusky cloud beneath stigma and junction of submarginal vein and marginal vein (Fig. 14). Legs pale yellow; pretarsi brown apically.

Head in frontal aspect 1.2× wider than high; compound eyes protuberant, asetose, 1.4× taller than length of malar space. Head surface alutaceous; vertex, medial margin of compound eye, face, and clypeal margin with



Figs. 7–8. Dorsal view of *Zagrammosoma nigrolineatum.*

sparse vestiture of pale, fine setae; clypeal margin straight. Torulus situated halfway between imaginary transverse line connecting ventral margins of compound eyes and eye midline.

Antenna (Fig. 9) 9-segmented (1, 1, 2, 2, 3); scape setose, alutaceous, 5.0× longer than wide; pedicel 1.6× longer than wide, setae more robust than setae on scape; alutaceous; anelli transverse, setose, smooth; funiculars subequal in length, setose and bearing rhinaria; club compact, 1.7× longer than wide, wider than funiculars, setose, each subsegment with rhinaria. Mandible 6-toothed. Maxillary palpus 1-segmented; labial palpus 1-segmented.

Mesosoma except metanotum alutaceous; meson of metanotum smooth, lateron striate. Posterior margin of pronotum with a line of fine, pale setae; scapula laterally with pale, fine setae; mesoscutum with 5 pairs of fine setae; scutellum with 2 pairs of fine, pale, long setae; metanotum asetose; propodeal callus with long, fine, pale setae, medial carina weakly developed but complete.

Metasoma oblong-ovate from above, 1.16× longer than mesosoma, alutaceous; posterior margin of terga with lateral line of setae incomplete on terga 1–3 but progressively increasing in number mesally such that line is complete on segments 4–7; apical ½ of tergum 1 uniformly setose; sterna mesally setose; ovipositor extending from base to apex of metasoma, 1.96× longer than hind tibia, 2.1× longer than middle tibia, 5.19× longer than gonostylus. Pygostylus well developed, apparently with 4 long and 1 short setae.

Forewing moderately setose distal to junction of submarginal vein and marginal vein; admarginal area asetose on dorsal surface of wing; costal cell with a line of setae; marginal fringe short.

Male.—Unknown.

Described from eight females taken at Coalinga, California during August 1939 from parasitized *Bucculatrix* sp. on cottonwood by F. P. Roullard. Holotype and female paratypes deposited in the U.S. National Museum of Natural History (USNM Type 75665).

This species is similar to Z. *multilineatum* but can be distinguished from that species based on the following characters: Z. *melinum* lacks a medial longitudinal stripe on the scutellum and apical hind tibial spot, and the intensiveness of setation on the forewing is considerably less.

Variation.—Although the type-series is not extensive, there does appear to be some color variation. The propodeum may be pigmented, the mesoscutal stripe may be complete and the mesal portion of the metasomal tergum may be pigmented.

Etymology.—The specific name is from Latin (*melinus*) and means yellow-colored.

Zagrammosoma mirum Girault
Figs. 6, 10

Zagrammosoma mirum Girault, 1916:119–120.

Type-locality.—Claremont, California.

This species was described from a single specimen. It is similar to Z. *flavolineatum*, and topotypical material of both species should be collected to determine whether they are conspecific. Only the type-specimen of Z. *flavolineatum* exists, but several specimens of Z. *mirum* have been accumulated in the U.S. National Museum, Natural History, collection. The characters that distinguish these species are the pale propodeal callus and pale basal ½ of the hind femur on Z. *flavolineatum*, and the uniformly dark

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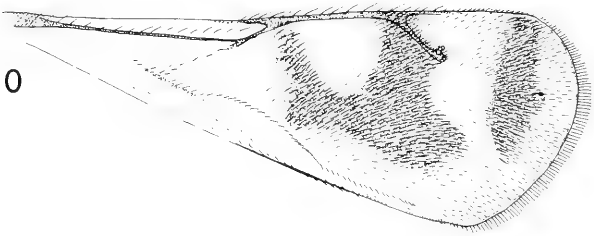

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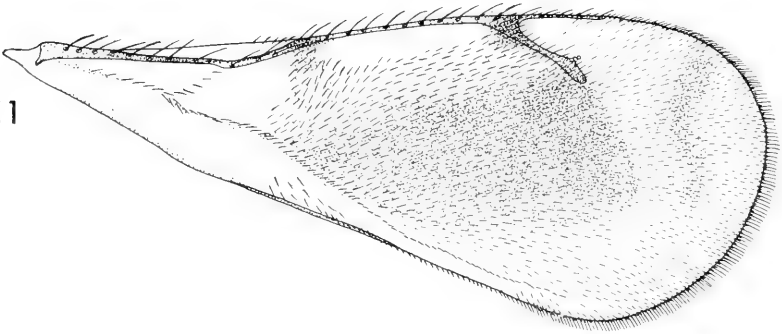

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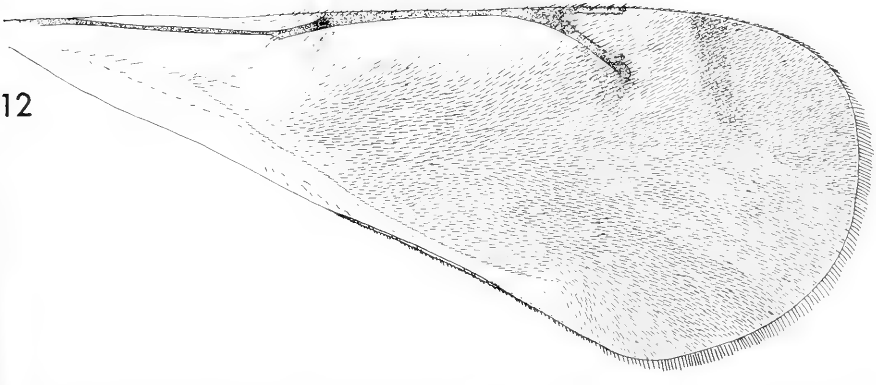

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Fig. 9. Antenna of *Zagrammosoma melinum.* Figs. 10–12. Forewings of *Zagrammosoma* species. 10. *Z. mirum*; 11. *Z. intermedium*; 12. *Z. multilineatum.*

coloration of the propodeum and dark hind femur with pale apex on *Z. mirum.*

Graf (1917) discussed a species he called *Z. flavolineatum* which attacked potato tuber moth, *Phthorimaea operculella* (Zeller), in Southern California. The illustrations of Graf's parasite lead me to conclude that he was dealing with *Z. mirum* because the coloration of the hind femur and propodeal callus is identical with that species.

Hosts of *Z. mirum* include *Lithocolletis* sp., *Tischeria* sp. and *Liriomyza pictella* (Thomson).

Zagrammosoma multilineatum (Ashmead)
Figs. 3, 12

Hippocephalus multilineatum Ashmead, 1888:VII.

Type-locality.—Riley Co., Kansas.

Zagrammosoma multilineata var. *punicea* Girault, 1911:123.

Zagrammosoma interlineatum Girault, 1916:125–126. NEW SYNONYMY.

Type-locality.—District of Columbia.

In Girault's original description of *Z. interlineatum* he compared the species to *Z. multilineatum.* I find no structural characters to differentiate the two, and the color pattern of *interlineatum* is within the range of variation exhibited by *Z. multilineatum.* Therefore, the synonymy is proposed.

Ashmead (1888) described *multilineatum* from two specimens and wrote that the species was characterized by a longitudinal stripe extending from the base of the torulus to the clypeal margin and two lines extended beneath the compound eye. The type-specimens also have a longitudinal stripe along the central third of the hind femur and a dark apical spot on the outer surface only. Since Ashmead's description this species has been recovered from Florida west to Idaho, Puerto Rico, and South America. Kerrich (1969) has provided supplementary descriptive notes on this species based on two specimens.

Not all of the material identified as *Z. multilineatum* in the U.S. National Museum, Natural History, collection conforms to the type-specimens. I have noted four phenotypes: (1) presence of a "nose" stripe, two stripes beneath the compound eye, and a stripe on the hind femur; (2) absence of a "nose" stripe, spotless and stripeless hind femur and convergent stripes beneath the compound eye; (3) absence of the "nose" stripe, stripes beneath the compound eye and spotless and stripeless hind femur; and (4) absence of the "nose" stripe, presence of two convergent stripes beneath the compound eye and a stripe and spot on the hind femur. There is geographical overlap among the phenotypes. Careful biological study of this species is necessary to determine whether sibling species are involved.

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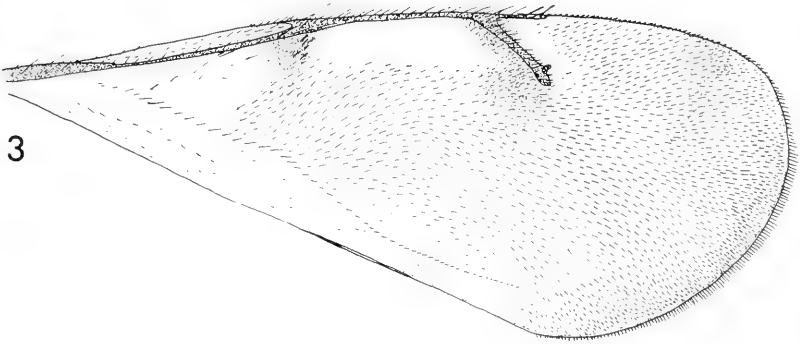

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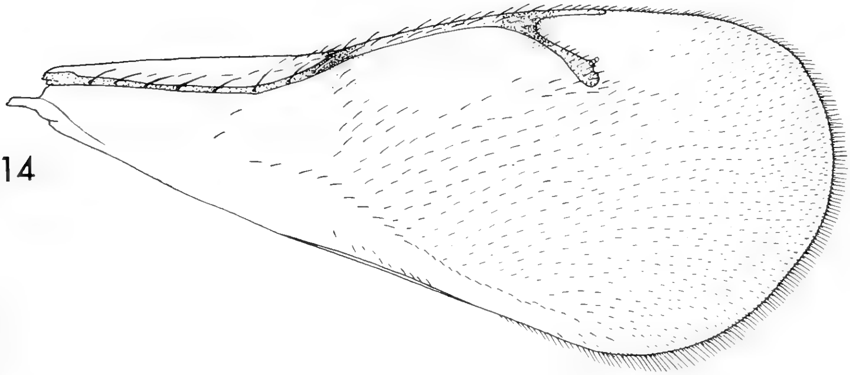

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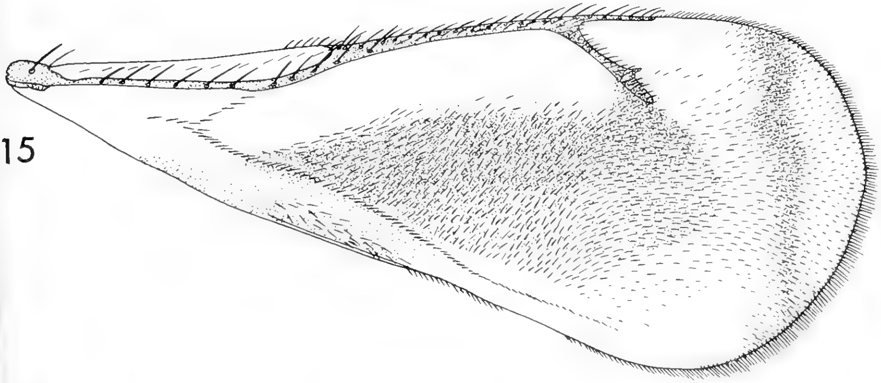

Figs. 13–15. Forewings of *Zagrammosoma* species. 13. *Z. americanum*; 14. *Z. melinum*; 15. *Z. centrolineatum*.

Girault (1911) named a "variety" of *Z. multilineatum* called *puniceum* from four specimens parasitizing *Tischeria malifoliella* Clemens taken by Quaintance at Washington, D.C. Girault reported that the distinguishing character was coloration, *Z. multilineatum* "variety" *puniceum* was pink and *Z. m. multilineatum* was yellow. When comparing Girault's type-material with other specimens of *Z. multilineatum*, I noted that the stripes beneath the compound eye converge, there is no "nose" stripe and the hind femur has a dorsal stripe and an apical stripe. Although Girault emphasized the difference in color, it is probably a cyanide induced reaction and I do not consider *puniceum* a subspecies.

The problem is complicated further because the specimens are labeled "Zagrammosoma multilineatum var amoverta MS, Girault," but apparently not in Girault's handwriting. The specimens are card-point mounted, and the type number is 9641. The U.S. National Museum, Natural History, type-catalog holds this name, but apparently Girault changed the name after it was entered in the catalog and before the manuscript was published.

This species is the most abundantly collected *Zagrammosoma* in North America and has been recovered from many hosts including Diptera and Lepidoptera. The most common hosts include: *Bucculatrix canadensisella* Chambers, *Coleotechnites milleri* (Busck), *Lithocolletis ostensackenella* (Fitch), *Antispila nyssaefoliella* Clemens, *Phyllonorycter craetaegella* (Clemens), *Agromyza pusilla* (auct., nec Meigen) and *Liriomyza sativae* Blanchard.

Zagrammosoma nigrolineatum Crawford
Figs. 7, 16

Zagrammosoma nigrolineatum Crawford, 1913:257.
Type-locality.—Compton, California.
Zagrammosoma sanguineum Girault, 1916:133. NEW SYNONYMY.
Type-locality.—Colorado.

Crawford's original description indicates that this species was based on two females, but examination of the type-series shows that they are both males. Several females have been acquired over the past 60 years; consequently, the following description can be provided.

Female 1.8 mm long. Head yellow except for 2 dark brown longitudinal stripes on frons, 3 spots surrounding ocelli, 2 occipital stripes, 2 large spots originating near oral fossa extending dorsally on either side of hypostomal bridge toward occipital foramen then diverging toward posterolateral margin of compound eyes; prementum dark; dark spot between toruli. Thorax yellow except metallic green lateral longitudinal and medial longitudinal stripes on pronotum, most of mesoscutum, scapulae along notauli; mesal ⅓ of scutellum and meson of metanotum. Entire propodeum except supracoxal flange metallic green. Posterior margin of proepisternum, ventral

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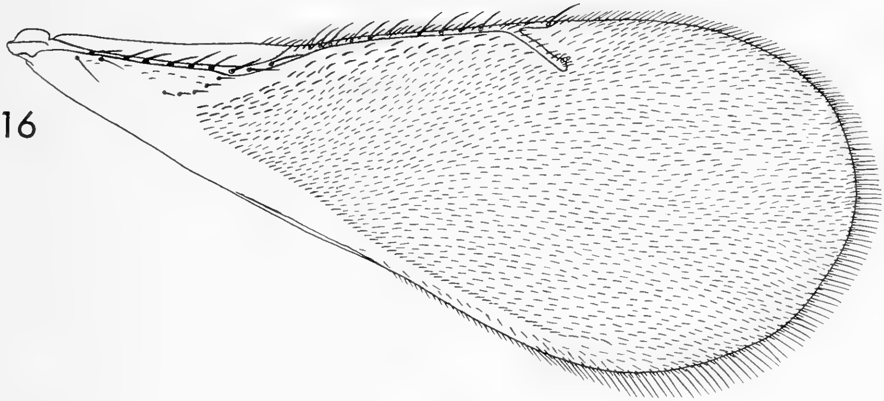

Fig. 16. Forewing of *Zagrammosoma nigrolineatum.*

0.33 of prepectus, ventral 0.50 of mesepisternum, mesepimeron dark. Metasomal terga predominantly dark reddish brown; sterna mesally dusky, laterally yellow; gonostyli dusky. Coxae yellow (except base of hind coxa), trochanters yellow; femora yellow except dorsolongitudinal stripe on front femur, base of hind femur; tibiae and tarsi dusky. Antennal scape with dorsal stripe; pedicel, anelli dark brown, funiculars and club slightly lighter.

Head in frontal aspect 1.33× wider than tall; compound eyes not strongly protuberant. Vertex and frons alutaceous; face, malar space smooth; compound eye 1.13× taller than malar space length. Head surface setose, compound eye setose, setae moderately long, pale; clypeal margin straight; toruli beneath imaginary transverse line extending between compound eyes, separated by 1.5 torular diameters. Antenna 9-segmented (1, 1, 2, 2, 3); scape reaching vertex, with reticulate striae, 5.70× longer than wide, with a few pale, thin setae; pedicel 2.0× longer than wide, moderately setose, usually about 1.5× longer than 1st funicular segment; anelli transverse with small, pale setae; funicular segments subequal in size, bearing setae and rhinaria; club 2.23× longer than wide with setae, rhinaria. Mandible 5-toothed. Maxillary palpus 2-segmented; labial palpus 1-segmented.

Mesosoma with alutaceous sculpture; pronotum with a row of moderately large setae on posterior margin; mesoscutum with 2 or 3 pairs and scutellum with 2 pairs of large setae; scapula with 5 setae; axilla and metanotum asetose; metanotal apex mesally pointed, displacing anterior portion of propodeum; propodeal median carina not reaching posterior margin; callus with moderate vestiture of pale, long, thin setae.

Metasoma smooth, 1.16× as long mesosoma; terga 1–3 setose laterally, 4–5 with transverse line of setae, 6–7 with uniform vestiture of pale, thin setae; sterna sparsely setose mesally. Ovipositor 1.11× as long as hind tibia, 1.19× as long as middle tibia, 4.0× as long as gonostylus; ovipositor extending from basal ⅓ of metasoma to apex. Pygostylus as long as wide, with 2 long and 3 short setae.

Forewing submarginal vein 1.17× longer than marginal vein; stigmal vein 1.3× longer than postmarginal vein; costal cell with a line of setae and a few setae along anterior apical margin; marginal fringe 0.07× maximal wing width.

Described from numerous specimens collected in Canada and the western United States. Hosts include *Coleotechnites milleri* (Busck) on *Pinus contorta* and *Jacaranda acutifolia* infested with *Phytoliriomyza jacarandae* Steyskal and Spencer M.S., *Argyresthia pilatella* Braun, and *Ocnerostoma strobivorum* Freeman.

Variation.—The color pattern of this species varies considerably. A long series of specimens taken at Targhee, Idaho by J. H. McLeod from cotton leafminer shows that the body coloration varies from pale yellow to a metallic blue-green mesosoma and reddish-brown metasoma. Ratio of pedicel length to first funicular segment length sometimes has been used as a taxonomic character. However, in this species the ratio is variable; the pedicel may be longer or shorter than the first funicular segment. Occasionally there are supernumerary setae on the scutellum. The ocelli always have dark spots surrounding them. Pale specimens have small spots; extensively metallic specimens have the entire interocellar area pigmented. This species has been recovered from *Apanteles* spp. attacking leafminers in Canada.

Girault (1916) described *Z. sanguineum* based on one female taken in Colorado. The type-specimen has the head crushed on a slide and mounted in Canada balsam and the body point-mounted. The body is red, but again I suspect that this is a cyanide-induced reaction. Although the antennae are broken, the pedicel is definitely longer than the first funicular segment. Morphologically this specimen falls within the range of variation exhibited by *Z. nigrolineatum* and thus the synonymy is proposed.

Acknowledgments

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NEOTYPE DESIGNATION OF *CULEX QUINQUEFASCIATUS* SAY (DIPTERA: CULICIDAE)

Sunthorn Sirivanakarn and Graham B. White

Abstract.—To promote nomenclatural stability concerning the interpretation and use of the name *Culex quinquefasciatus* Say for the southern (tropical) house mosquito, a neotype male is here designated. It was chosen from a series of specimens reared from an egg raft, collected in 1969 at New Orleans, Louisiana, USA. Description and illustrations of the *quinquefasciatus* male, female and associated pupa and larva are provided. Under the Law of Priority, the name *quinquefasciatus* Say 1823 takes precedence over all accepted junior synonyms, notably *fatigans* Wiedemann 1828.

In the intervening two decades since the name *Culex quinquefasciatus* Say (1823:10) was discussed by Stone (1956 [1957]:342–343) and adopted by Stone et al. (1959) as the valid name for the southern (tropical) house mosquito, some significant contributions have been made towards an objective resolution of the nomenclatural arguments concerning this well known taxon. Fundamental to the solution of this problem is the identity and nomenclatural status of the only surviving mosquito specimens that were collected by Thomas Say. These were sent by Say to Wiedemann between 1823 and 1828 and later were deposited in the Naturhistorisches Museum in Vienna. Among this material are specimens which Wiedemann (1828:12–13) described as *Anopheles ferruginosus*. In a footnote he stated that the description was based on "original" specimens of *Culex quinquefasciatus* (i.e., material from Say but not necessarily type-material, see Belkin, 1977:44).

In 1905, L. O. Howard (*in* Coquillett, 1906:7) examined four specimens labelled as *ferruginosus* and reported that they were *Culex*, not *Anopheles*. This discrepancy has led subsequent culicidologists to suspect or speculate that some of the specimens in the type-series of *ferruginosus* may represent the original material from which Say (1823:10–11) drew his description of *quinquefasciatus*. If this were the case it would be possible to select and designate one of these specimens as a lectotype of *quinquefasciatus*, thus removing all doubts about the identity of the species to which this name has been applied.

In an attempt to clarify and to resolve the above and other intimately related problems, Belkin (1977:45–52) critically reexamined all existing Say material of mosquito species described by Wiedemann (*ferruginosus*, *crucians* and *pungens*) at the Naturhistorisches Museum in Vienna in the summer of 1966. Of the 4 so-called *ferruginosus* specimens mentioned by

Coquillett (1906), Belkin found only 3 with determination labels from Wiedemann. These 3 specimens represent an *Anopheles* species conforming to Wiedemann's description of *ferruginosus* but not to Say's description of *quinquefasciatus.* The fourth specimen lacks a definite determination label, and was identified by Belkin as *Culex.* As discussed by Belkin, Howard probably saw this specimen; but, as it bears no Wiedemann labels, it cannot be taken as type-material of any species described by Wiedemann, particularly *Culex pungens* to which it apparently belongs. This information rules out any possibility of designating a lectotype of *quinquefasciatus* from the existing *ferruginosus* syntype series.

The type-specimens of *Culex pungens,* and Wiedemann's description of this species, agree perfectly with Say's description of *quinquefasciatus* and it appears possible that *pungens* might have been described from original specimens of *quinquefasciatus.* However, as the *pungens* type-specimens cannot be proven to have come from Say, their standing in relation to *quinquefasciatus* is equivocal. Based on these lines of argument, derived from his examination of the *ferruginosus* and *pungens* material, Belkin (1977) concluded that the *ferruginosus* specimens are unacceptable as the original material (type) of *quinquefasciatus* and that Wiedemann's description of *pungens* was probably based on the specimens of *quinquefasciatus.* Other information from the description and labels of Wiedemann's species indicates New Orleans as the origin of the Say material. Although the exact locality of *quinquefasciatus* cannot be determined from Say's notes, it is safe to assume that some of the original material may have come from somewhere in the vicinity of New Orleans to where the type-locality was restricted by Belkin, Schick and Heinemann (1966:4–5).

From a careful consideration of the involved problems fully discussed by Belkin (1977) we are satisfied that none of the material from Say, as used for the description of *ferruginosus* Wiedemann, is eligible for designation as lectotype of *quinquefasciatus.* The rest of Say's original material is no longer existent in the United States. Harris, who studied the Thomas Say collection shortly after Say's death, reported that the Diptera were entirely destroyed (Weiss and Ziegler, 1931). Thus there seems to be no possibility that other original type-material of *quinquefasciatus* will be found for proper lectotype designation.

We also concur with Belkin (1977) that, since none of the *Anopheles ferruginosus* specimens can be considered as the original material (type) of *Culex quinquefasciatus,* a suitable neotype from New Orleans should be designated in order to clarify and to stabilize the nomenclature. In accord with the interpretation by Stone (1956 [1957]), as adopted in both editions of the World Catalog of mosquitoes (Stone et al., 1959:254; Knight and Stone 1977:217) and as analyzed further by Belkin (1968b:47; 1977: 45–52), we recognize that the original description of *quinquefasciatus* by Say (1823:10–11) applies to the *Culex* species commonly known as the tropical or southern house mosquito. Furthermore, it seems highly unlikely that Say, who described 6 North American Culicidae in the years 1823–1827, would have failed to name this familiar pest, and none of his other descriptions could readily be confused with it. In accordance with the Law of Priority (Article 23, International Code of Zoological Nomenclature, 1964:23; 1974:79–81), therefore, the name *quinquefasciatus* Say 1823 takes precedence over all accepted junior synonyms, notably *fatigans* Wiedemann 1828 (see Knight and Stone, 1977:217–219 for complete synonymy).

In support of previous and present interpretations of the name *quinquefasciatus*, the original description given by Thomas Say is reproduced in Fig. 1.

Neotype Designation and Depository

Neotype ♂ (No. 9) with associated pupal and larval skins and slide of genitalia (No. 691013-1), reared from an egg raft collected on 18 September 1969 in New Orleans, Louisiana, U.S.A., by personnel of the New Orleans Parish Mosquito Control (George T. Carmichael, director); to be deposited in the U.S. National Museum, Washington, D.C. (USNM).

Other specimens reared from the same egg raft as the neotype have been deposited in the following institutions:

(1) British Museum (Natural History), London, Great Britain: 1♂ (No. 11) with associated pupal and larval skins and genitalia slide (No. 691013-2), 1♀ (No. 2) with associated pupal and larval skins and 2 whole larvae.

(2) Services Scientifiques Centraux, O.R.S.T.O.M., Bondy, France: 1♂ (No. 17) with associated pupal and larval skins and genitalia slide (No. 691013-3), 1♀ (No. 5) with associated pupal and larval skins and 2 whole larvae.

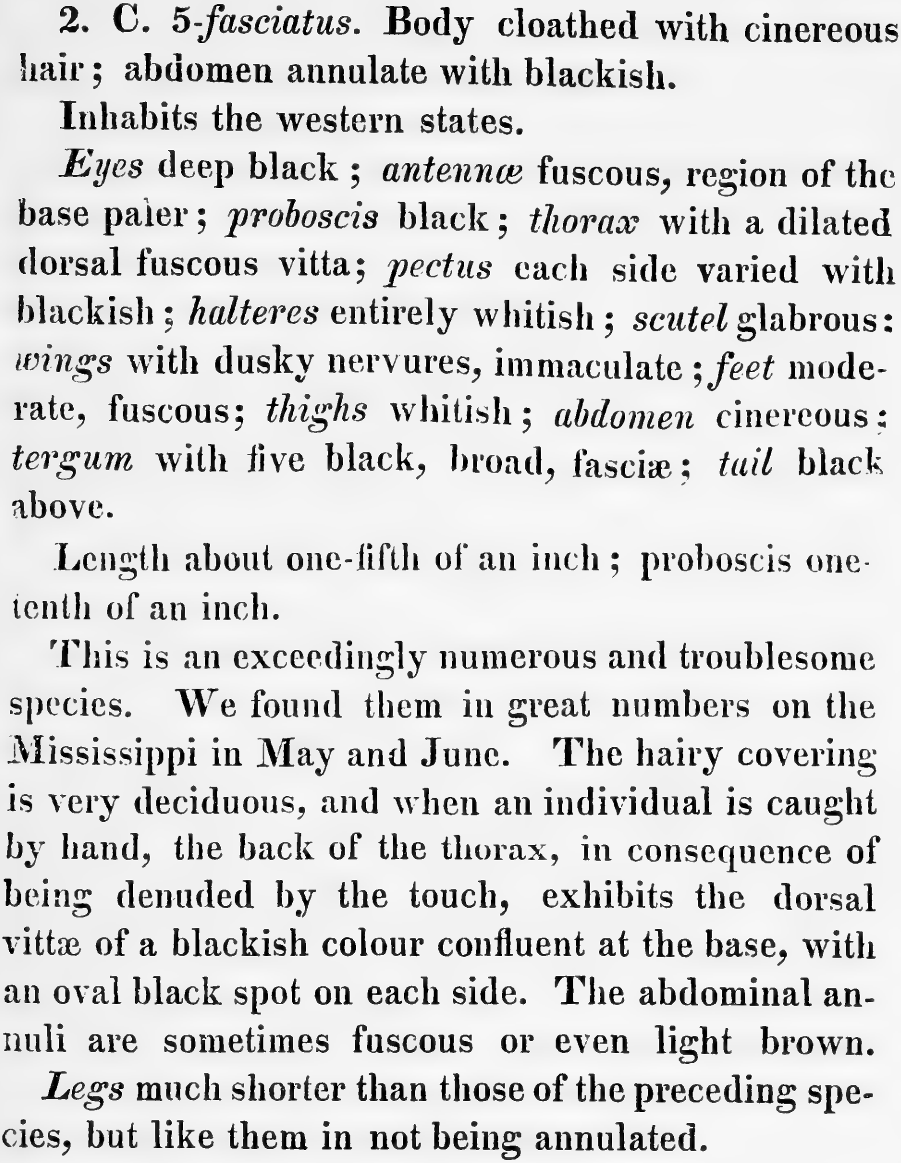
(3) Australian National Insect Collection, C.S.I.R.O., Canberra, Australia: 1♂, with slide of genitalia (No. 760318-1), 1♀ (No. 8) with associated pupal and larval skins and 2 whole larvae.

(4) Department of Entomology, National Science Museum, Tokyo, Japan: 1♂ with slide of genitalia (No. 760318-4), 1♀ with associated pupal and larval skins and 2 whole larvae.

The rest of the material in this series, which consists of 8♂ (3 with genitalia slides No. 760329-2, 3, 5), 4♀ with associated pupal and larval skins (No. 1, 15, 16, 18), 12♀ (2 with slides of cibarial armature No. 760329-1, 2) and several whole larvae are placed in the collection of the USNM. These specimens are available for deposition in other museums upon request.

Description and Illustrations

The description and illustrations of *quinquefasciatus* presented here are composite and comprehensive, based on a detailed study of the neotype and



2. C. 5-*fasciatus*. **Body cloathed with cinereous hair; abdomen annulate with blackish.**

Inhabits the western states.

Eyes deep black; *antennæ* fuscous, region of the base paler; *proboscis* black; *thorax* with a dilated dorsal fuscous vitta; *pectus* each side varied with blackish; *halteres* entirely whitish; *scutel* glabrous: *wings* with dusky nervures, immaculate; *feet* moderate, fuscous; *thighs* whitish; *abdomen* cinereous: *tergum* with five black, broad, fasciæ; *tail* black above.

Length about one-fifth of an inch; proboscis one-tenth of an inch.

This is an exceedingly numerous and troublesome species. We found them in great numbers on the Mississippi in May and June. The hairy covering is very deciduous, and when an individual is caught by hand, the back of the thorax, in consequence of being denuded by the touch, exhibits the dorsal vittæ of a blackish colour confluent at the base, with an oval black spot on each side. The abdominal annuli are sometimes fuscous or even light brown. *Legs* much shorter than those of the preceding species, but like them in not being annulated.

Fig. 1. Reproduction of the original description of "Culex 5-fasciatus" as published by Say, 1823:10–11.

all other specimens in this series. Altogether, 43 specimens (13 males, 20 females, 10 fourth instar larvae) and 11 associated pupal and larval skins have been examined. The descriptive terminology used follows Belkin (1962, 1968a) and Belkin et al. (1970). For a brief diagnosis of the adults and im-

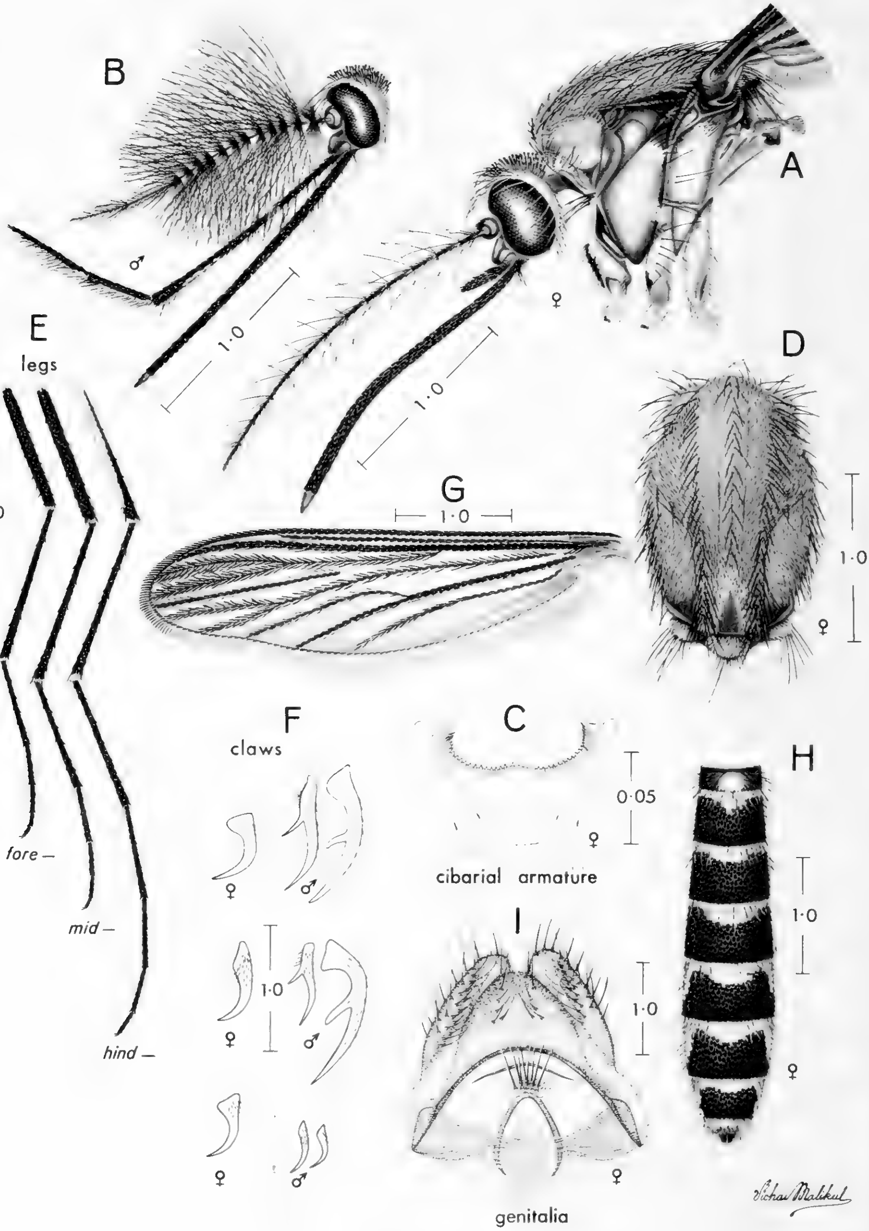


Fig. 2. *Culex quinquefasciatus.* A, female head and thorax, lateral view; B, male head, lateral view; C, female cibarial armature; D, female thorax, dorsal view; E, legs, anterodorsal views; F, male, female tarsal claws; G, wing, dorsal view; H, female abdomen, dorsal view; I, female genitalia.

matures of *quinquefasciatus*, consult Belkin (1962, 1968a), Bram (1967) and Sirivanakarn (1976).

Male (Fig. 2).—Measurements based on neotype. Wing 3.6 mm. Forefemur 1.8 mm. Proboscis 2.7 mm. In general as described for female except for the following. Head: Palpus exceeding proboscis by full length of segment 5; segments 2 and 3 entirely dark scaled; segment 3 sometimes with a few pale scales on lateral surface in middle, apical 0.25–0.40 with a ventrolateral tuft of 10–12 dark bristles, ventral surface with a row of several short, pale hairlike setae extending from base to apex; segments 4 and 5 entirely dark scaled on dorsal surface, lateral, ventral and mesal surfaces with numerous bristles; ventral surface of segment 4 with a pale scaled line from base to about 0.75 of total length; ventral surface of segment 5 with a distinct pale scaled spot at base. Proboscis entirely dark scaled or sometimes with a poorly defined pale ring at false joint which is located at about 0.75 of the length from base. Antenna shorter than proboscis, flagellar whorl long, densely plumose. Legs: Claws of fore- and midlegs enlarged, external claw larger than internal, both with a distinct subbasal denticle; claws of hindleg small, equal and simple. Wing: Scales on branches of veins R, M and Cu less dense than those in the female. Abdomen: Tergites II–VII with complete, evenly broad basal pale bands, all of which are connected with basolateral pale spots laterosternad; length of basal band about ⅓ of segment width.

Male genitalia (Fig. 3A).—Segment IX: Tergal lobe poorly developed, with 1–2 irregular rows of 10–12 strong setae; sternum broad, finely spiculate, without setae or scales. Sidepiece: Slender, conical, about 0.35 mm in length; inner tergal surface with 1–2 irregular rows of about 15 subequally strong setae extending from basal ⅓ to slightly beyond level of subapical lobe; lateral tergal surface with about 20 heavy bristles and several weaker bristles; apex with a row of 6–7 setae on sternal surface. Subapical lobe: Broad; specialized setae of proximal and distal divisions clearly divided; proximal divisions with 3 strong rodlike setae (*a*–*c*) of subequal length; rod *a* straight with abruptly pointed apex; rods *b* and *c* gently curved with hooked apices; rod *c* thinner than *a* and *b*, its base more or less separated from the latter distad; distal division with 3 slender bladelike or rodlike setae in group *d*–*f* on mesal surface and 1 broad leaflet (*g*) and 1 strong flattened seta (*h*) on lateral surface. Clasper: simple, typically sickle-shaped, about 0.75 of length of sidepiece; outer subapical margin without distinct annulation or crest of spicules; 2 ventral tiny setae present distad of median curvature on ventral surface, dorsal seta absent; spiniform subapical, short, flattened and apically blunt. Phallosome: Apical portion of lateral plate with outer and inner divisions; median portion of outer division with a prominent apically pointed tergal mesal spine (or tergal arms of several authors) which is straight so that both spines on each lateral plate are nearly

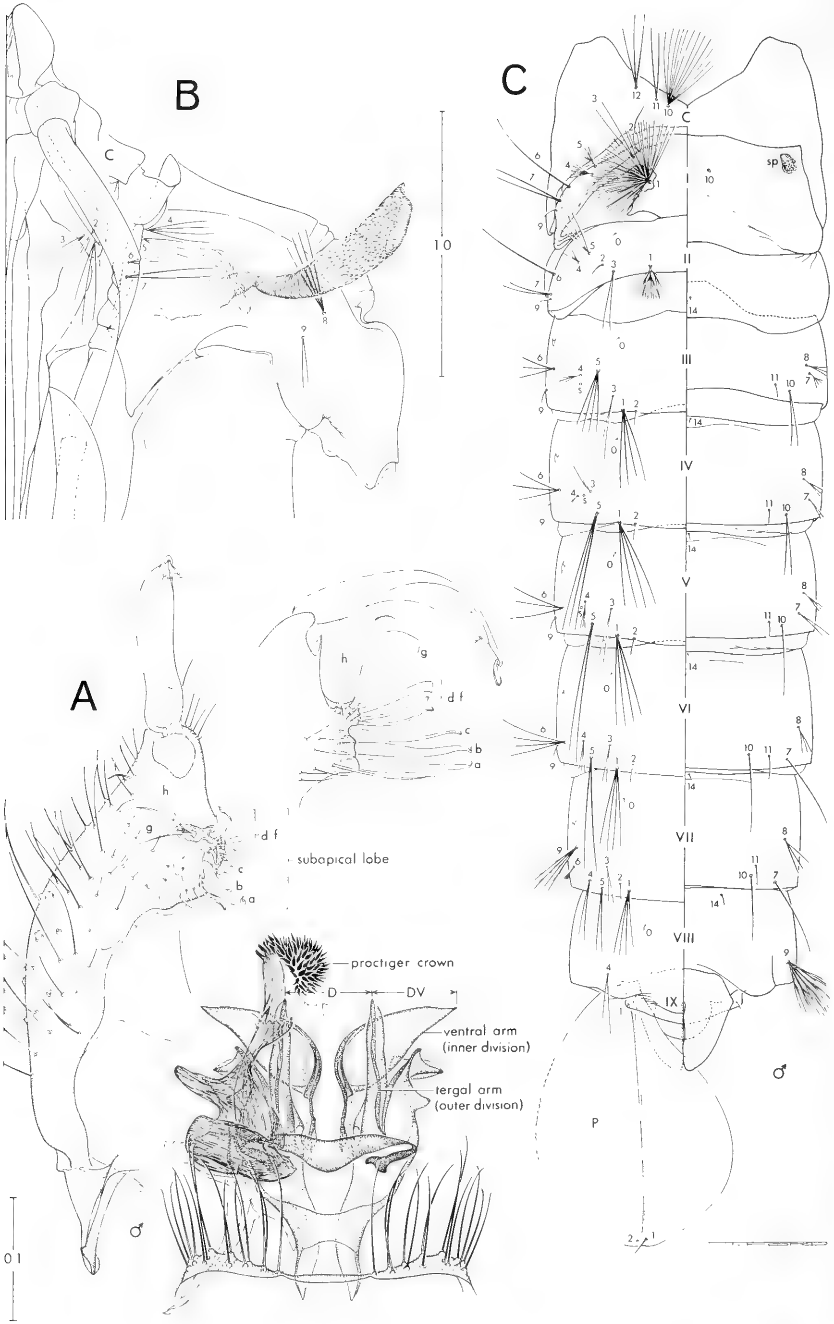


Fig. 3. *Culex quinquefasciatus*. A, male genitalia, dorsal view; B, pupa, cephalothorax, C, pupa, cephalothorax, abdomen and paddle.

parallel; lateral portion of outer division with a small or weakly sclerotized, divergent lateral spine and a small, apically rounded lateral basal process; inner division represented by a simple, broad, leaflike ventral arm which is sharply pointed and strongly divergent laterad; DV/D ratio [or distance between apices of tergal mesal spine and ventral arm (DV)/distance between apices of tergal mesal spines (D)] usually 1, varies from 0.7–1. Proctiger: Apical crown large, dark, composed of 4–5 flat and blunt spicules laterally and numerous spinelike spicules laterally and mesally; paraproct well sclerotized; basal sternal process rudimentary or poorly developed, at most 0.03 mm in length; cercal sclerite poorly sclerotized; cercal setae 3–4.

Female (Fig. 2).—Wing 4.2 mm. Forefemur 1.98 mm. Proboscis 2.3 mm. Abdomen 3.24 mm. General coloration light brownish. Head: Eyes contiguous above antennal pedicels; decumbent scales on dorsum of vertex narrow, crescent-shaped, rather coarse and predominantly pale beige in center, fine and whitish on orbital line; erect scales numerous, evenly spread, largely dark brownish except for a few pale ones in center; lateral patch of broad appressed scales whitish; frontal bristles strong, yellowish or golden; upper orbital bristles weaker, dark brownish; suborbital bristles weak, pale yellowish to dark brownish. Clypeus bare, integument dark brownish. Palpus 4-segmented, about 0.2 of proboscis length, largely dark scaled, apex of segment 4 usually tipped with some pale scales on inner dorsal surface. Proboscis completely dark scaled on labium; labial basal setae 4 with 2 lateral ones strong and as long as palpus and 2 median ones weaker and shorter. Antenna slightly shorter or as long as proboscis; pedicel with a distinct patch of semi-erect scales and setae on inner dorsal surface; flagellum 13-segmented; flagellar segment 1 with or without a few pale scales; 5–6 flagellar bristles, very weak and sparse, their length about 2× as long as one flagellar segment. Cibarial armature: Cibarial dome oval, strongly imbricate; cibarial bar evenly concave except for slight projection at middle; about 30 teeth, all short, apices blunt, truncate or abruptly pointed; 3–4 median teeth weakly developed and lightly pigmented, lateral teeth stronger and dark pigmented. Thorax: Mesonotal integument brownish or lighter, but not blackish; mesonotal scales narrow, crescent-shaped and dense, more or less uniformly pale beige or dull yellowish on disc, pale whitish on extreme anterior promontory, lateral margin of supra-alar, middle of prescutellar space and scutellar lobes; acrostichal bristles well developed in a double row from anterior promontory to near prescutellar space; dorsocentral and supra-alar bristles strong; mid-scutellar lobe with 7–8 bristles, lateral scutellar lobe with 6–7 bristles. Integument of pronotum same color as mesonotum; anterior pronotal lobe (*apn*) with 6–8 strong bristles and several pale scales on dorsal surface. Posterior pronotum (*ppn*) with a broad patch of narrow, pale beige scales on anterior upper surface; 5–6 strong, dark posterior bristles. Pleural integument paler than

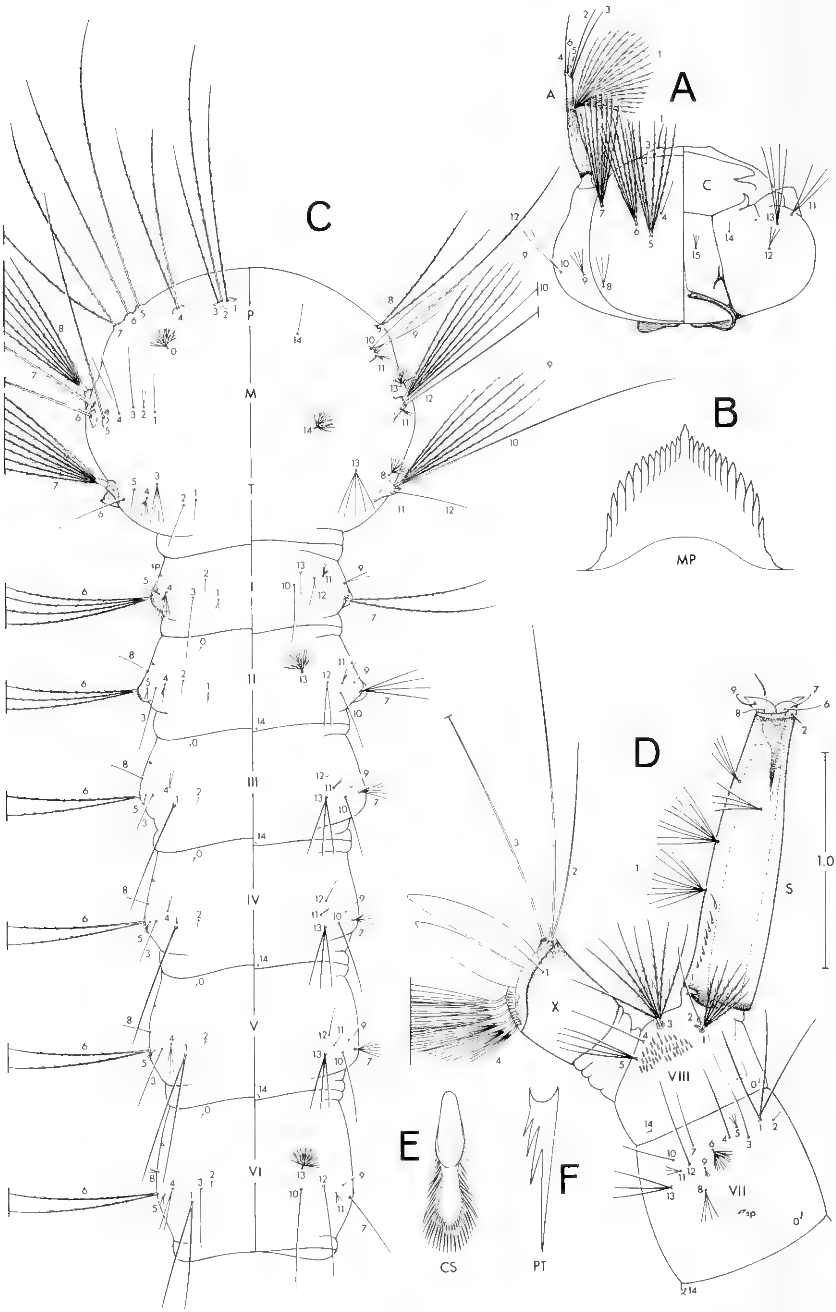


Fig. 4. *Culex quinquefasciatus*, larva. A, head; B, mental plate; C, thorax and abdomen I–VI; D, abdomen VII, VIII, siphon and saddle; E, comb scale; F, pecten tooth.

mesonotum and without definite pattern of darkened areas; whitish scale patches present, distinct, restricted to propleuron (*ppl*), sternopleuron (*stp*) and mesepimeron (*mep*); *ppl* with a small scale patch at base on lateral surface; *stp* with a broad scale patch on uppermost corner and a separate vertical scale patch along posterior border; *mep* with a broad scale patch at same level as upper corner of *stp* and several loosely packed scales among upper mesepimeral bristles; *ppl* with 5–7 bristles and 5 other weak setae; lower *mep* bristles 1–2 and sometimes 3; upper *mep* bristles about 10. Legs: Anterior surface of forecoxa with several strong, curved bristles and a broad scale patch, latter largely dark on lower surface, pale whitish, forming a distinct spot on upper lateral surface; anterior surface of mid- and hindcoxae with a narrow whitish scale patch; trochanters and bases of femora pale scaled; anterior surface of fore- and midfemora dark scaled, apex tipped with pale scales, ventral surface whitish scaled; anterior surface of hindfemur with a broad longitudinal pale stripe from base to apex, dorsal surface dark scaled, ventral surface whitish scaled; all tibiae dark on dorsal surface, apex tipped with pale scales, ventral surface pale; all tarsi completely dark or blackish scaled; claws of all legs small, equal and simple. Wing: Scales on all wing veins dark and dense; plume scales on R_2, R_3 and R_{4+5} narrow, linear; cell R_2 about 3× as long as length of R_{2+3}; furcation of cell M_2 at same level as or slightly distad of furcation of cell R_2; alula fringed with a row of 12–14 dark, narrow scales; upper and lower calypters fringed with numerous long, yellow, hairlike setae. Halter: Peduncle pale and bare; knob cupshaped, covered with several pale scales. Abdomen: Tergites II–VII with distinct basal pale bands and basolateral pale spots, latter on tergites II–V not distinct from above; tergum I with dark caudal scale patch, basal bands on tergites II–V broadened in middle, narrow laterally and not connected with basolateral pale spots; basal bands on tergites VI–VIII evenly broad and connected with basolateral pale spots or streaks which are visible from above; sternites predominantly yellowish. Genitalia: Sternite VIII with distinct median emargination; lateral caudal margin with a row of 7–8 strong, curved bristles, median caudal margin with several weaker bristles. Tergite IX narrow with an irregular row of about 10 bristles on lateral caudal margin, median portion bare. Cerci short, thumblike, about 0.15 mm in length, with numerous setae largely restricted to apical lateral surface. Postgenital plate rounded on posterior caudal margin, apical 0.5 with a double lateral row of 6–7 bristles, with 1–2 of most distal bristles strongest. Posterior cowl narrow, ribbonlike, with numerous spicules. Vaginal sclerite horseshoe-shaped or in form of a U. Sigma with a dense tuft of 8–9 strong setae.

Pupa (Fig. 3B, C).—Abdomen 3.6 mm. Paddle 0.90 mm. Trumpet 0.72 mm; index 5. Detailed chaetotaxy as figured. Cephalothorax: Yellowish white with indefinite darkened areas along margin of posterior middorsal ridge, leg and wing cases; setae 1- to 3-C triple; 5-C 4–5 branched; 8-C usually 3–4 branched (2–4); 9-C 2–3 branched. Trumpet: Meatus narrow and dark in basal 0.25, apical 0.75 gradually broadened or more or less cylindrical and pale; apical margin truncate or slightly emarginated; pinna oblique and long, 0.30–0.38 of total length. Metanotum: Darkened in middle, pale laterad; seta 10-C 8–10 branched; 11-C double; 12-C 3–4 branched (2–5). Abdomen: Segments I–IV darkened in middle, pale towards lateral margin; segments V–VIII uniformly pale yellowish to whitish; setae 3-I to 3-III double, 3-III sometimes single; 5-II and 5-III 4–5 branched; 6-I and 6-II single; 7-I and 7-II double; 1-II small, brushlike, dendritic, with 15–16 distal branches; 1-III to 1-VI subequal, 4–5 branched, 0.50–0.75 of length of segment following; 1-VII shorter, usually 4 branched (3–4); 5-IV to 5-VI strong, as long as or slightly longer than segment following; 5-IV usually triple, sometimes double; 5-V and 5-VI double; 6-III to 6-V subequal, usually triple (2–4); 6-VI stronger, usually 4 branched (3–4); 4-VII double; 9-VII usually 4 branched (3–4); 9-VIII 5–8 branched. Paddle: Very broad, hemispherical; color whitish to almost transparent; external buttress and midrib distinct, but not infuscate; outer margin smooth or minutely spiculate; setae 1-P and 2-P minute, single.

Larva (Fig. 4).—Head 0.78 mm. Siphon 1.3 mm; index 4. Saddle 0.38 mm; siphon/saddle ratio 3.3. Detailed chaetotaxy and general features as figured. Head: Broader than long; integument pale yellowish from level of ocular bulge to anterior margin of frontoclypeus, darker posteriorly, collar brownish; ocular bulge prominent; labrum narrow; seta 1-C pale, proximally flattened, distally filamentous, its length about 0.5 of the distance between bases of the pair; 4-C single, as long as or slightly longer than the distance between bases of the pair; 5-C and 6-C usually 5 branched (4–6), strong, subequal, their apices reaching slightly beyond mouthbrush; 7-C 8–10 branched, slightly shorter than 5-C and 6-C; 13-C 4 branched; 14-C single; 16-C and 17-C not developed. Antennal shaft 0.50–0.75 of head length, straight or weakly curved outward in middle; proximal portion with numerous strong spicules, distal portion beyond base of setae 1-A with or without a few spicules; pigmentation same as head capsule; 1-A large, fan-shaped, with about 22 strongly pectinate branches; 2-A and 3-A single, bristlelike and pale, both situated subapically. Mental plate brownish, with 10–13 lateral teeth on each side of a median tooth. Mouthbrush composed of numerous long, yellowish filaments. Thorax: Integument glabrous; setae 1-P to 8-P strong, subequal, 1-P to 3-P single; 4-P double; 7-P usually double, sometimes triple or 4 branched; 8-P usually double, sometimes triple or 4 branched; 14-P single; 3-M single; 4-M double; 8-M 6–8 branched; 9-M and 9-T 5–6 branched; 7-T 7–10 branched; 12-T single; 13-T 3–7 branched. Abdomen: Segment I–IV: Integument glabrous; setae 6-I and 6-II usually 4 branched, sometimes 3; 7-I double, sometimes triple;

1-III to 1-VI strong, 0.50–0.75 of seta 6-III to 6-VI, 1-III and 1-IV usually single, sometimes double; 1-V and 1-VI double; 6-III to 6-VI all double. Segment VII: Seta 1-VII 3–4 branched; 3-, 7-, 10- and 12-VII single; 4-VII single or double. Segment VIII: Lightly spiculate; comb scales 30–40, all broad, short, subequal, apical fringe rounded, composed of evenly fine spicules; seta 1-VIII 5–6 branched; 2-VIII and 4-VIII single; 3-VIII 7–8 branched; 5-VII 4 branched. Saddle complete, pigmentation whitish or light yellowish; spiculation and sculpture practically absent or poorly developed; posterior caudal margin weakly spiculate; seta 1-X single, very distinct; 2-X with 1 short and 1 long branch; 3-X single; 4-X (ventral brush) consists of 6 pairs of setae, all inserted within grid; anal gills stout, apex pointed, as long as or slightly longer than saddle length. Siphon: Rather stout and thick, somewhat fusiform; acus present, blackish, tube yellowish with variable amount of brownish tinge; pecten teeth developed, 6–12 in a ventral lateral row from base to about 0.3 of total length of siphon; 3–4 distal teeth with 3 graded strong basal denticles and 1 spinelike apical denticle; siphonal tufts 4 pairs (total 8), placed beyond pecten; 2 proximal pairs strong, subequal, 6–8 branched, as long as siphonal width at point of attachment; 2 distal pairs reduced, 4–6 branched; most distal pair placed subventrally, the other more proximal, laterally; seta 2-S pale, single, spiniform; median caudal filament of spiracular apparatus developed and distinct.

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(SS) Medical Entomology Project, Smithsonian Institution, Washington, D.C. 20560; and (GBW) Department of Entomology, British Museum (Natural History), London SW7 5BD, Great Britain.

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AN INFESTATION OF MILTOGRAMMINE SARCOPHAGIDAE (DIPTERA: SARCOPHAGIDAE) IN A POPULATION OF *HYBOMITRA LASIOPHTHALMA* (MACQUART) (DIPTERA: TABANIDAE)

Patrick H. Thompson

Abstract.—A second isolation of *Macronychia* sp. near *aurata* (Coquillett) was made from adult specimens of Tabanidae in south-central Texas. Fifty-nine sarcophagid larvae were obtained from 270 adult females of *Hybomitra lasiophthalma* (Macquart) which were taken 7–14 April 1977, inclusive, during their peak emergence on the Navasota River floodplain near College Station, Texas. The apparent high incidence of parasites in this tabanid population (22%) is qualified by the observed frequency of multiple parasitism; of 4 parasitized females dissected, 3 suffered multiple infestations of 2, 3 and 5 larvae, respectively. The chronology of parasitization of *H. lasiophthalma* by this sarcophagid suggests that the tabanid serves as a first host species for the parasite, while species of *Tabanus*, such as *Tabanus subsimilis subsimilis* Bellardi, act as hosts of subsequent generations of parasites. Once again, the parasite was found infesting *T. s. subsimilis*.

The isolation of miltogrammine sarcophagid larvae from adult females of *Tabanus subsimilis subsimilis* Bellardi was reported by Thompson (1978). That particular infestation involved a population of this tabanid collected near Easterwood Airport and the sewage treatment plant, College Station, Texas 28 May through 14 July 1976. Subsequently, the sarcophagid parasite was identified as *Macronychia* sp. near *aurata* (Coquillett), hereafter referred to as *Macronychia* sp. The 1978 report considered the chronological and ecological details coincident with the parasitization; methods of rearing the parasite, and its larval behavior; relevant biology for the host and for the parasite; and the implications of these findings for the known life histories of miltogrammine sarcophagids and for the management of noxious populations of Tabanidae.

During a study of *Hybomitra lasiophthalma* (Macquart) the following year, *Macronychia* sp. was again observed commonly infesting females of the host species. The details of this sarcophagid-tabanid association will be compared with those previously recorded for *Macronychia* sp. and *T. s. subsimilis* (Thompson, 1978).

Studies of reproductive physiology of Tabanidae, preparatory to rearing work, were begun with the first spring dominant found in the vicinity of College Station. All females of *Hybomitra lasiophthalma* collected during

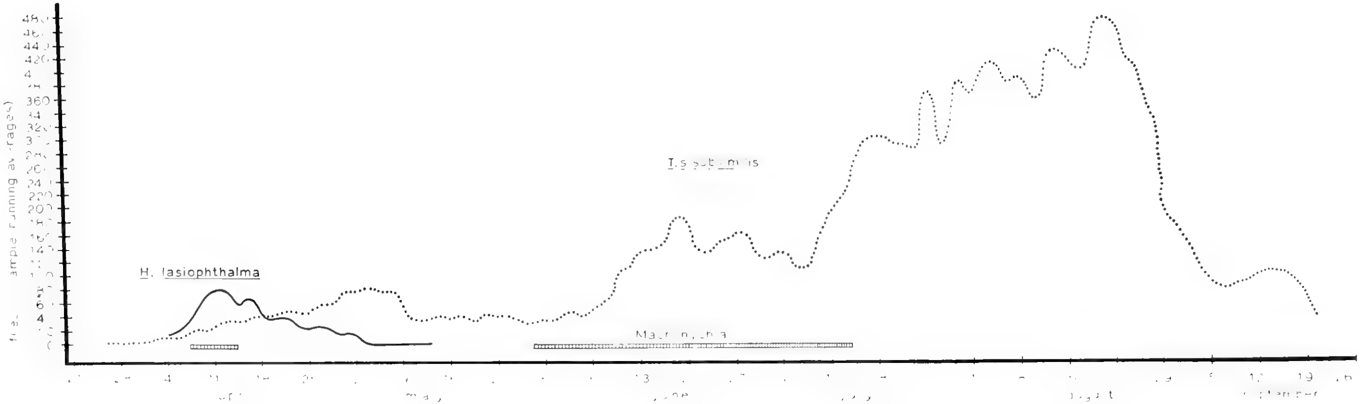

Fig. 1. Seasonal distributions of *Hybomitra lasiophthalma* and of *Tabanus subsimilis subsimilis*, showing periods of infestation by *Macronychia* sp.

Table 1. Daily catches of *Hybomitra lasiophthalma* females taken 7–14 April 1977, inclusive, and numbers of infesting *Macronychia* sp. larvae emerging from them.[a]

	Day of April								
	7	8	9	10	11	12	13	14	Totals
No. tabanids	22	34	28	22	42	47	40	35	270
No. sarcophagids	1	6	5	1	5	32	6	3	59
Percent infested	4	18	18	4	12	68	15	9	22

[a] Eleven larvae were excepted; these were found in the abdominal cavities of dissected females.

the period 7–14 April, inclusive, from two Manitoba Traps located on the Navasota River, were held in the lab to observe additional instances of parasitism. Catches were augmented with CO_2 generated from dry ice.

Methods

All dead *H. lasiophthalma* females removed from holding cages in the laboratory were retained together by date in 10-dram glass vials. The centers of the polyethylene lids of these containers were cut out with a heated No. 12 cork borer; and the lids were subsequently lined with a 25-mm disc of 70-mesh brass screen (Brass Strainer Cloth, C. O. Jellif Corp., Southport, Connecticut 06490). These vials of dead flies were examined daily for the presence of parasite larvae and the first larvae were found on 8 April, when they emerged from dead *H. lasiophthalma* females trapped the day before. Sarcophagid specimens were reared on decapitated crickets in glass Petri dishes. Parasites removed from flies taken on the same date were reared together. Further details of rearing were previously described (Thompson, 1978).

Observations

A total of 59 sarcophagid larvae was removed from vials containing 270 adult females of *H. lasiophthalma*. More than half of these (32) emerged from host specimens taken on 12 April, the 6th day of collection (Table 1). Mortality of the larvae was very high (81.4%) in contrast to that suffered by the lesser number of specimens reared from *Tabanus subsimilis subsimilis* (17.7%; Table 2).

Development and behavior.—The periods of parasite larval development and of pupal development, under the same physical conditions as for *T. s. subsimilis*, were considerably longer (Table 2). The high mortalities and attenuated development of parasites found in *H. lasiophthalma* could reflect microbial infection. Again, larval behavior was scavenger like; but

Table 2. Summary data of *Macronychia* sp. infestations in *Hybomitra lasiophthalma* and *Tabanus subsimilis subsimilis.*[a]

	H. lasiophthalma	*T. s. subsimilis*
No. larvae collected	59	27
No. larvae reared	11	14
no. females	7	4
no. males	4	10
Mortality rate (%)	81.4	17.7[b]
Larval period (days)	8–14, avg. 10.3	2–8, median 6
Pupal period (days)	18–20, avg. 18.8	15–17, avg. 15.9
No. tabanid adults	270	3,000 (est.)
Parasitism rate (%)	3–22	1 (est.)
Parasite loads	1,2,3,5 (4)	7,8 (2)

[a] Data on *Tabanus subsimilis subsimilis* presented in detail in Thompson (1977).

[b] Rate based upon 17 larvae reared, rather than 27, because 10 were preserved for taxonomic purposes.

also again, parasites attacked dead hosts via intact cervical membranes (4 instances).

Discussion

Briefly, miltogrammine Sarcophagidae are cleptoparasites of wasps and bees. The two North American species of *Macronychia*, in particular, have been reared from nests of two sphecid wasp genera. The findings relating to tabanid parasitism described here, conflict with those supporting a cleptoparasitic, and thus secondarily parasitic life history for this species.

Multiple parasitism.—First, as with *Tabanus subsimilis subsimilis*, the occurence of multiple infestations in one host suggests that such larvae were specimens that originated together from the same females foraging near the host. (In 3 of 4 host infestations examined in vivo, 2, 3 and 5 larvae were found together in the abdominal cavity.) Secondly, these larvae were the same size.

If these assumptions regarding multiple infestations by sibling larvae are correct, the mode of life of *Macronychia* sp. could be that of a primary parasite. Although another order of insects was involved, Dr. Paul Arnaud of the California Academy of Sciences, San Francisco, called my attention to a documented instance of such primary parasitism by a miltogrammine species. From 2 camel crickets, he isolated 7 larval specimens of *Hilarella hilarella* (Zetterstedt)—specimens which subsequently pupated and emerged (Arnaud, 1954). Dr. K. V. Krombein, Smithsonian Institution, suggested that *Macronychia* species could normally parasitize Diptera and that apparent instances of these flies parasitizing the prey of sphecid wasps could, instead, represent primary parasitism of other species of Diptera before they fall prey to the wasps (Krombein, personal communication).

Rate of parasitism.—The parasite-host ratio was estimated because host females of *Hybomitra lasiophthalma* were not isolated individually. Assuming that 59 larvae infested host flies singly, this rate would be 22%; conversely, if 8 parasites infested each host (8 was the most observed), this rate would be 3%. Obviously, the actual rate lies between 3% and 22%.

One factor would surely have increased this rate. Dissections of only a few *H. lasiophthalma* females produced 4 specimens with dead or dying larval parasites. Therefore, unless this small sample is atypical, many infesting parasites never completed development.

The host.—(A review of this tabanid, currently in preparation, will detail and document information in the following summary.) Presently, *H. lasiophthalma* is one of the most widespread and abundant species of its genus in North America, extending from British Columbia to Nova Scotia, and south to Texas and Georgia. In southern Canada and the northern United States, where the larvae breed extensively in sphagnum bogs and shrub-sedge marshes, the adults emerge in June and July. As this form extends southward through the eastern states, its distribution is largely confined to rivers where it breeds predominantly in heavy organic soils of floodplain forests and where its seasonal distribution constricts and recedes, the adults emerging over a shorter period in spring, rather than through midsummer, as farther north. In such riverine localities, and their surrounding ridges, this horse fly is often a dominant species and a major pest of cattle and horses. Parity in *H. lasiophthalma* has been described and females oviposit a blackish, tar-like mass of eggs on the leaves of reeds, sedges, cattails and shrubs growing in low areas which locally characterize the larval habitat. As is also typical of other North American species of *Hybomitra* and *Tabanus*, the adults commonly feed on nectars (this is often evidenced by pollen grains on the mouth parts of trapped specimens); often pursue rapidly-moving vehicles; fly near roadside puddles and woodland pools where they frequently touch the water surface, or "dip," as they circle above it; and hover in sunlighted woodland openings (males), probably in frequent association with mating. This tabanid was one of the first North American species reared in the laboratory from eggs collected in the field; and as with the eggs, the larvae and the pupae have been observed and collected from lowland habitats in nature. In addition, the immatures and both sexes of the imago have been described. *Hybomitra lasiophthalma* has been the subject of other studies involving physiology and disease transmission.

The relationship.—Most significant to the association described here, are the chronological facts causally relating populations of the parasite to those of the two known host species of the Navasota River floodplain and its adjacent uplands. *Macronychia* sp. was first observed in *Tabanus subsimilis subsimilis* during the period 28 May through 14 July 1976; and the following year, in *Hybomitra lasiophthalma*, from 7 through 14 April. Although these infestations were observed in different years, their chronology suggest that *H. lasiophthalma* could serve as an important host for the first generation of sarcophagids; then the 2nd and subsequent generations of the parasite could infest populations of *Tabanus s. subsimilis* or other numerous forms found during the summer months (Fig. 1).

The curve for *T. s. subsimilis* presented here is based upon collections made in the uplands during the previous year (1975; Thompson, 1977); this curve closely corresponds with that taken in the lowlands the same year, but for the following reservation. Catches at the river declined in August, 1975 because of flooding, whereas catches in the uplands continued to increase for 3 weeks after that.

The 6-week interim between infestations of the two host populations, as depicted in this figure, could account for a projected trough between generations, as based upon development times observed in the laboratory (Table 2).

Concerning the seasonal distribution of *Tabanus s. subsimilis*, intensive collections of adults through most of the year in several Texas ecosystems showed that this species, in contrast to *Hybomitra lasiophthalma*, is aseasonal; i.e., it is found continuously throughout 9 months of the year and peaks anytime during most of that period—from late March to late May (Thompson, 1975) or in late summer (Thompson, 1977). Therefore, this horse fly is abundantly accessible as a potential host insect during most of the season.

A second infestation of Tabanus subsimilis subsimilis.—*Macronychia* sp. was again isolated from this species, in this case, from bottomland populations collected with catches of *Hybomitra lasiophthalma.* Two females which had been held in the laboratory for 3 and 7 days, respectively, contained 2 small 2nd-instar larvae (1 female, 12 April); and 1 large 1st-instar larva (1 female, 8 April). Of these specimens observed in the abdominal cavity, one larva in each fly was alive when it was found.

Conclusions

As with *Tabanus s. subsimilis*, the circumstances surrounding collection and retention of *Hybomitra lasiophthalma* preclude any reasonable possibility of unnatural parasitism. With both species, specimens were removed from trap collection containers within the laboratory and were then held alive in the lab with small numbers of their own species *(H. lasiophthalma*) or of other *Tabanus* species (*T. s. subsimilis*). No other insects or extraneous materials of any kind were contained in any cages of either species. In addition, no miltogrammine sarcophagids were found in Manitoba Trap catches containing infested specimens of these tabanid species. (Several miltogrammine species of other genera have been taken in small numbers from Gressitt Traps.) In fact, the Manitoba Traps used during these and similar studies of the past 13 years, have taken very few numbers of few species of other insects. Finally, infested horse fly specimens were found in numerous samples of the 2 species—8 in the case of *H. lasiophthalma* and 7 for *T. s. subsimilis*; and these samples were isolated from one another in containers inaccessible to other insects the size of *Macronychia.*

The incidence of *Macronychia* parasitism in Tabanidae is now well documented. The extent of this association with the 2 host tabanids named here, and of others locally abundant, remains to be defined by further survey. Parasite-host specificity, and consequent high rates of parasitism, could offer a potential means of managing pest populations of species which otherwise remain unmanaged.

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Veterinary Toxicology and Entomology Research Laboratory, Fed. Res., Sci. Educ. Admin., USDA, College Station, Texas 77840.

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THE ALLOTYPE OF *ARENASELLA MALDONADOI* AND CHANGE OF DEPOSITORY FOR TWO OF FENNAH'S HOLOTYPES (HOMOPTERA: TROPIDUCHIDAE AND ISSIDAE)

J. Maldonado Capriles and Angel Berríos

Abstract.—The male allotype of *Arenasella maldonadoi* Caldwell is described from specimens collected from the type-locality. The holotypes of *Tangella pustulifrons* Fennah and *Colpoptera galatea* Fennah are transferred to the collection of the U.S. National Museum of National History (USNM), Washington, D.C.

Caldwell (1951) described the second species of *Arenasella* from female specimens collected by the senior author near the Recreation Area at El Yunque National Forest, Luquillo, Puerto Rico. We now describe the male allotype from a series of specimens collected from almost the same place. The specimens were collected from a bromeliad (*Guzmania* sp.). This fulgoroid protects itself during the day by living under the sheaths of the leaves that form the base of the plant.

Fennah (1965) described *Tangella pustulifrons* from specimens collected by the senior author at Christiana, Jamaica and *Colpoptera galatea* from St. John, Barbados, and he deposited the holotypes in Maldonado's (JMC) collection. These types now have been transferred to the collection of the USNM.

Tropiduchidae

Arenasella maldonadoi Caldwell, 1951:224.

The characters of the male agree closely with those of the female. Head as illustrated in Figs. 1, 2 and 3. Forewing 2.5× as long as broad, Fig. 7. The apex of the clavus is as described by Caldwell for the female, but the correct venation of the apical half of the forewing is as in Fig. 7. Some of the longitudinal veins are missing in Caldwell's drawing. The mesopleurite has a black spot. We think Caldwell meant the last thoracic sternite instead of "abdominal sternite" as there is a conspicuous black spot on the posterolateral corner of the metapleura almost hidden by the

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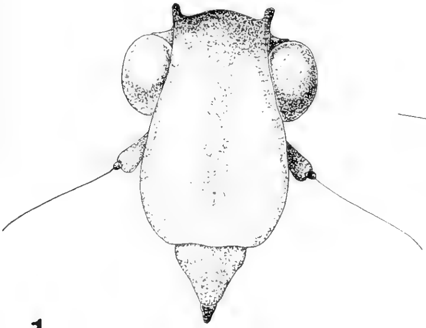
Figs. 1–7. *Arenasella maldonadoi* Caldwell, male. 1. Head, frontal; 2. Head and pronotum, dorsal; 3. Head and pronotum, lateral; 4. Genital capsule and aedeagus, lateral; 5. Aedeagus, dorsal; 6. Aedeagus, ventral; 7. Forewing.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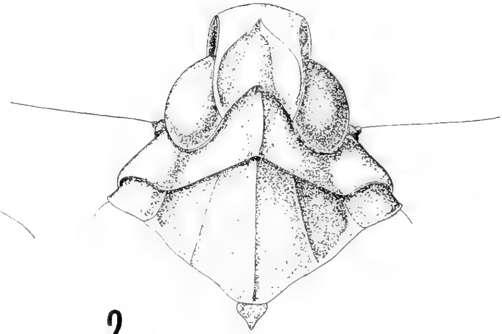
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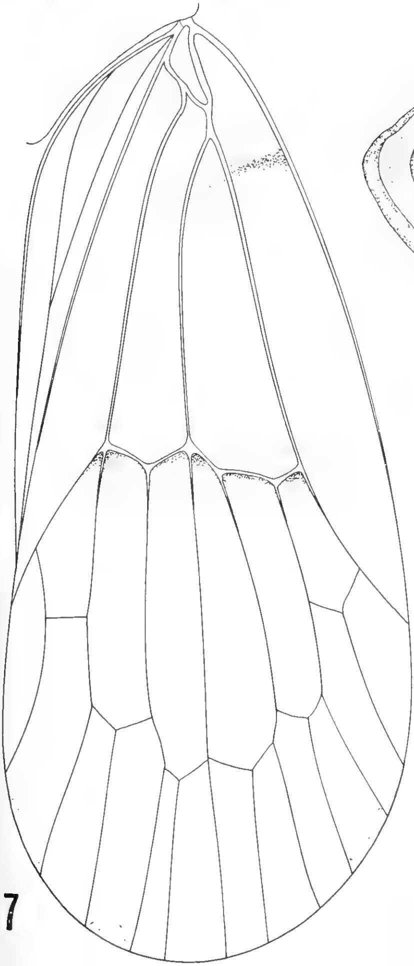
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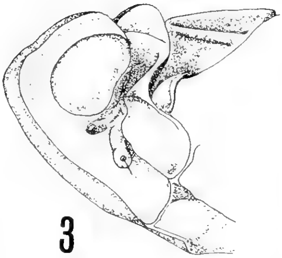
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abdomen. Ventrally near base of the anterior coxa there is a small black spot. This last spot is inconspicuous in the females at hand and not mentioned by Caldwell. Looking at the insect from the ventral side the spots on the procoxa, mesopleura, and prebasally on the costa of the forewing are distributed arc-like. These spots are also visible in lateral view. The last abdominal sternum has a conspicuous spot at the lateral extremity. Length 4.9–5.0 mm.

Genital segments as in Figs. 4–6.

Allotype, male, Puerto Rico, El Yunque National Forest, 20–22 March 1954, J. Maldonado Capriles and S. Medina collectors, in the USNM. Three paratypes in the USNM, two in the collection of the Department of Entomology of the Agriculture Experiment Station of the University of Puerto Rico, Río Piedras, and one in JMC.

Tangella pustulifrons Fennah

Tangella pustulifrons Fennah, 1965:99.

Male holotype formerly in JMC, now in the collection of the USNM, Type No. 75328.

Issidae

Colpoptera galatea Fennah

Colpoptera galatea Fennah, 1965:103.

Male holotype formerly in JMC, now in the collection of the USNM, Type No. 75329.

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Department of Biology, University of Puerto Rico, Mayaguez, Puerto Rico 00708 (JMC now at: Department of Anatomy, School of Medicine, Catholic University of Puerto Rico, Ponce, Puerto Rico 00731).

PROC. ENTOMOL. SOC. WASH.
80(3), 1978, pp. 383–387

TWO NEW *CERATOCAPSUS* REUTER 1876, FROM THE EASTERN UNITED STATES (HEMIPTERA: MIRIDAE)[1]

Thomas J. Henry

Abstract.—Two new species of *Ceratocapsus* are described: *Ceratocapsus spinosus* from Pennsylvania and *C. aurantiacus* from Florida. The adult of *C. spinosus* and the male genitalia of both species are illustrated.

While examining light trap material from the Frost Entomological Museum, Pennsylvania State University, I discovered two new species of *Ceratocapsus* from the United States. One species, taken at the Archbold Biological Station in Florida is the first truly orange-red *Ceratocapsus* and the other species, taken in western Pennsylvania is the largest member of this genus. They are described and illustrated here.

Ceratocapsus spinosus Henry, new species
Figs. 1–5

Male.—Length 5.83 mm, width 2.0 mm; impunctate, generally fuscous to black, clothed with fine, short setae, intermixed with erect, pilose setae. Head: Length 0.82 mm, width 0.96 mm, vertex 0.34 mm, dorsal width of eye 0.30 mm; black, shiny, finely granulate, not punctate, median line shallowly grooved, basal carina distinct. Rostrum: Length 1.80 mm, brown, reaching middle of mesocoxae. Antennae: I, length 0.62 mm, light brown, with several erect, stout setae; II, length 2.04 mm, weakly thickened to apex, brown to dark brown, especially on apical ½, clothed with fine, recumbent, brown to black setae, fewer at base; III, length, 0.92 mm, dark brown; IV, length, 0.80 mm, dark brown. Pronotum: Length 1.00 mm, width at base 1.60 mm, finely granulate, shiny, black becoming lighter or more brown at base, void of pubescence; mesoscutum black; scutellum black, apex brown, transversely rugose, sparsely set with brown, pilose setae. Hemelytra: Brown, somewhat alutaceous, clothed with short, recumbent, pale setae intermixed throughout (except on embolium and cuneus) with brown, pilose setae; cuneus fuscous to black; corium appearing darker due to fuscous abdomen beneath. Membrane: Translucent, more fumate on apical ½, veins colored as membrane. Venter: Shiny fuscous to black, ostiolar peritreme pale, abdomen clothed with recumbent, pale setae, those setae on genital segment longer. Legs: Uniformly brown, hind tibiae somewhat darker; setae and tibial spines colored like segments. Genitalia: Left paramere three pronged (Figs. 2, 3); basal prong at right angle to middle prong, with 2 distinct subapical spines; dorsal margin

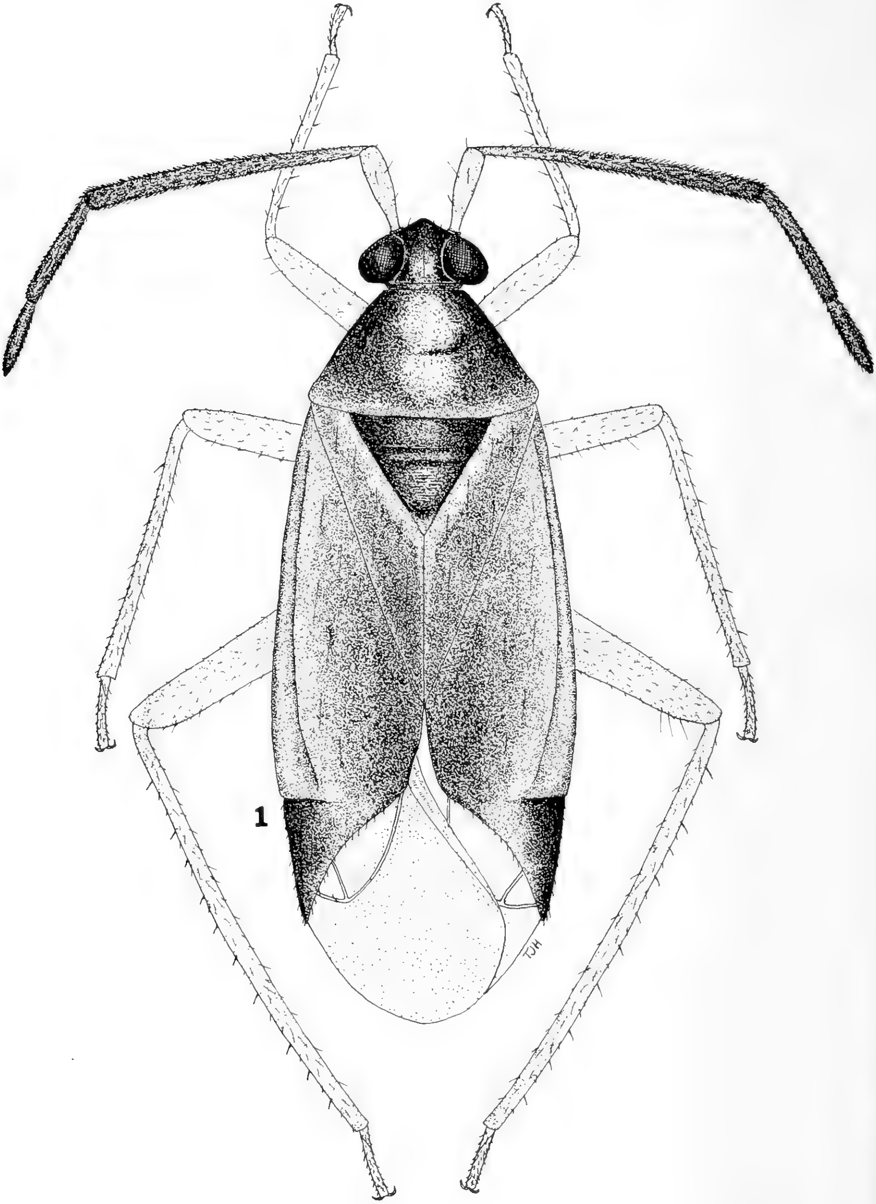


Fig. 1. *Ceratocapsus spinosus*, habitus.

of middle prong with 1 spine; right paramere simple, relatively straight (Fig. 4) basal process simple and blunt; theca (Fig. 5).

Female.—Unknown.

Holotype.—♂, Pennsylvania: Beaver Co., Pa., Rt. 168, 6 mi SW of Darlington, 4 August 1975, Mrs. M. A. Carter collector (USNM type #74022). Paratype: ♂, 1 August 1975, same data as holotype (PSU collection).

Remarks.—*Ceratocapsus spinosus* keys to *nigrocephalus* Knight in Knight (1923, 1941), but differs from it by the larger size, the uniformly black cuneus, the brown corium, the relative lengths of the antennal segments and the structure of the male genitalia.

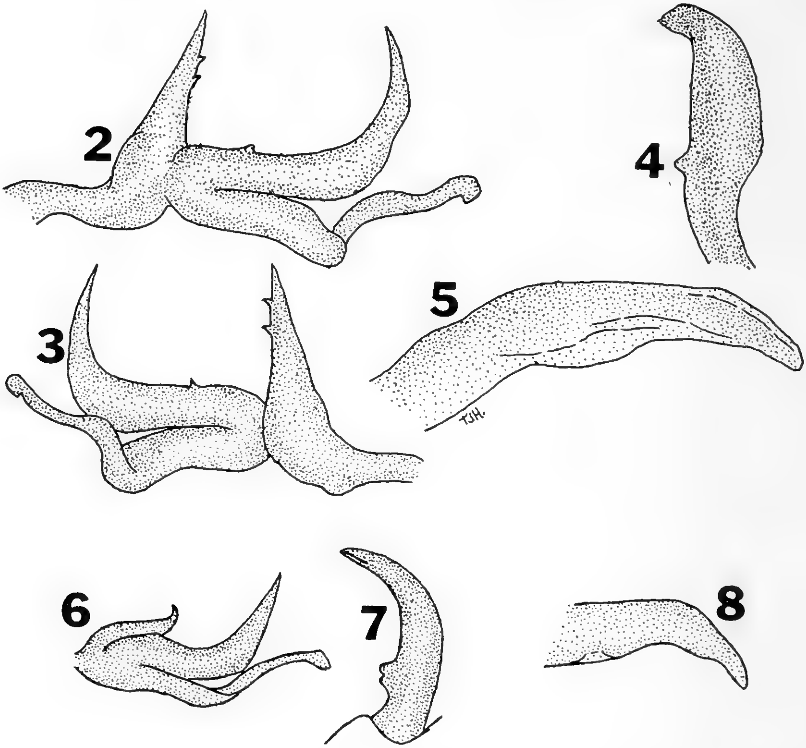
This species may be separated from all other *Ceratocapsus* by the large size, the black head, pronotum, scutellum and cuneus, the brown hemelytra clothed with pilose setae and the male genitalia. The basal prong of the left paramere bears two subapical barbs or spines which easily characterize this species and are the basis for the name *spinosus.*

Ceratocapsus aurantiacus Henry, new species

Figs. 6–8

Male.—Length 3.36 mm, width 1.48 mm, impunctate, general color orange to orange red, clothed with pale to silvery, sericeous pubescence, intermixed with more erect, pale setae. Head: Length 0.68 mm, width 0.78 mm, vertex 0.30 mm, orange, sparsely set with erect, pale setae; eyes reddish. Rostrum: Length about 1.30 mm (imbedded in glue), reaching posterior margin of metacoxae. Antennae: I, length 0.38 mm, pale testaceous; II, length 1.06 mm, pale testaceous, apex lightly tinged with orange; III, length 0.64 mm, testaceous, tinged with orange; IV, length 0.52 mm, pale orange or reddish. Pronotum: Length 0.70 mm, width at base 1.20 mm, shiny orange to reddish orange, sparsely set with erect and semierect, simple setae; mesoscutum orange; scutellum orange, more reddish just before apex, apex pale orange, weakly but distinctly rugose. Hemelytra: Generally orange to orange red; outer margin of corium, area just before cuneal fracture and cuneus distinctly orange red; sparsely set with semierect, pale setae, clavus and corium clothed with silvery, sericeous pubescence. Membrane: Fumate, veins colored like membrane. Venter: Orange to red, abdomen red, genital segment more orange and clothed with long, pale setae. Legs: Pale testaceous; tibiae weakly spined; claws and tarsi testaceous. Genitalia: Left paramere three pronged; basal prong short, appressed along dorsal margin of middle prong, apex strongly recurved (Fig. 6); right paramere sickle-shaped with basal process notched apically (Fig. 7); theca (Fig. 8).

Female.—Length 3.48 mm, width 1.60 mm. Head: Length 0.68 mm, width 0.78 mm, vertex 0.36 mm. Rostrum: Length about 1.10 mm (imbedded in



Figs. 2–5. *Ceratocapsus spinosus*. 2. Left paramere, lateral view; 3. Left paramere, inside lateral view; 4. Right paramere; 5. Theca of aedeagus. Figs. 6–8. *Ceratocapsus aurantiacus*. 6. Left paramere, lateral view; 7. Right paramere, lateral view; 8. Theca of aedeagus.

glue), reaching middle of mesocoxae. Antennae: Testaceous; I, 0.32 mm, red dash on inside margin; II, 1.14 mm, apex tinged with orange; III, 0.64 mm, apical ½ tinged with orange; IV, 0.46 mm, reddish orange, pale at base. Pronotum: Length 0.70 mm, width at base 1.24 mm. The females are similar to the male in color and form except for minor variation noted in the antennae.

Holotype.—♂, Archbold Biological Station, Highlands Co., Fla., 5-3-1967, S. W. Frost collector (USNM Type #75435). Allotype: ♀, same data as holotype, 5-5-1967 (USNM). Paratypes: 2♀, same data as other types (PSU collection).

Remarks.—*Ceratocapsus aurantiacus* keys to *taxodii* Knight or *vicinus* Knight (Knight, 1941) and to *vicinus* Knight (Blatchley, 1926), but differs from both species in color and the structure of the male genitalia.

Ceratocapsus aurantiacus is characterized most easily by the orange to orange-red color and the structure of the male genitalia. The basal prong of the left paramere is reduced but strongly recurved apically; the basal process of the right paramere is rather broad and apically notched. The name *aurantiacus* is derived from the Latin adjective *aurantium*, meaning orange.

Acknowledgments

I thank Dr. K. C. Kim of the Frost Entomological Museum, Pennsylvania State University for the loan of specimens and Drs. Kim, and K. R. Valley and A. G. Wheeler, Jr., Bureau of Plant Industry, Department of Agriculture for reviewing the manuscript, and Mr. G. C. Steyskal, Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. Educ. Admin., USDA for his suggestion and explanation of the name *aurantiacus*.

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The Frost Entomological Museum, Department of Entomology and the Pennsylvania State University, University Park, Pennsylvania 16802 (*mail address*: Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania 17120).

Footnote

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80(3), 1978, pp. 388–396

BIOLOGY AND IMMATURE STAGES OF *ANTICHAETA BOREALIS* (DIPTERA: SCIOMYZIDAE), A PREDATOR OF SNAIL EGGS

William H Robinson and B. A. Foote

Abstract.—Larvae of all investigated species of *Antichaeta* feed on snail eggs. Females of the North American *A. borealis* Foote oviposit directly onto egg masses of the snail *Oxyloma* sp., and all three larval instars feed solely on the eggs. The mature larva usually leaves the egg mass before forming a puparium. *Antichaeta borealis* is multivoltine in northeastern Ohio. Three species of Ichneumonidae, *Phygadeuon* sp. A, *Phygadeuon* sp. B and *Mesoleptus* sp., were reared from puparia collected in the study area. The egg, three larval instars and puparium are described and illustrated. The life histories of the reared species of *Antichaeta* are reviewed and compared.

The genus *Antichaeta* is one of the smaller genera in the family Sciomyzidae, consisting of 5 Palearctic and 8 Nearctic species. An undescribed species is known from Michoacan, Mexico (K. Valley, personal communication). Biological information is available for 7 of the 13 described species. Investigations of the biology and immature stages of *Antichaeta* species were conducted by Fisher and Orth (1964), Knutson (1966) and Knutson and Abercrombie (1977). Larvae of all investigated species feed on eggs of snails.

This paper outlines the life history and describes the immature stages of *A. borealis* Foote, a widespread North American species whose larvae attack eggs of terrestrial snails of the genus *Oxyloma* (Succineidae). Specific morphological features of the immature stages are illustrated in detail. Laboratory rearings and observations reported here are based on material collected during the spring and summer of 1965 at an extensive marsh located about 6 kilometers east of Kent, Ohio.

Biology of *Antichaeta borealis*

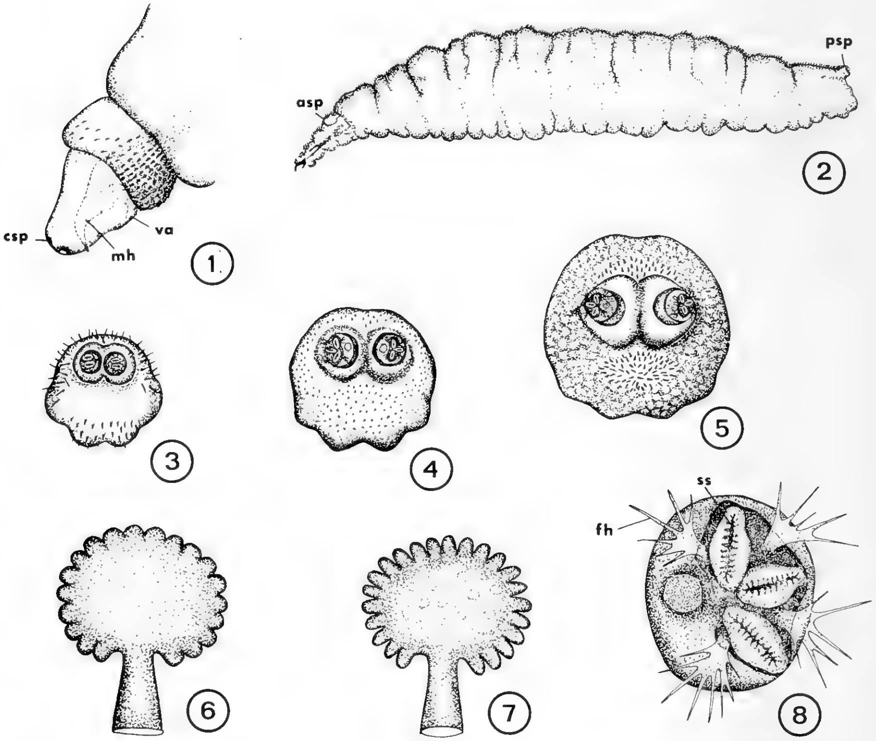
In northeastern Ohio, the only area where the biology was studied, adults and larvae were found most commonly in open, permanent marshes and frequently along the shaded borders of such areas. The habitat distribution of the fly is similar to that of the principal food snail, *Oxyloma* sp.

Recently emerged females of *A. borealis* had a premating period (from emergence to first copulation) of 24–36 hours. No specific courtship behavior was observed before mating. The mating position was similar to that of other species of the genus (Fisher and Orth, 1964; Knutson, 1966).

The male was situated dorsally and faced in the same direction as the female, with the anterior portion of his head (not including the antennae) extending to about the mid-length of the thorax of the female. The male's front tarsal segments were laid along her parafrontal areas, laterad to the fronto-orbital bristles and bending them slightly inward. The tarsi extended over the female's fronto-facial ridge, just laterad to her antennae. His middle legs remained free or occasionally rested on the basicostal margins of the female's half-outstretched wings. The hind tarsi of the male were placed on the abdomen of the female. Copulation was not restricted to any particular part of the day, and often lasted an hour. Adults mated frequently before and after oviposition.

Egg masses of *Oxyloma* sp. (probably *O. retusa* (Lea)) apparently provide the only natural oviposition site for *A. borealis.* Although laboratory-reared females also readily oviposited onto egg masses of *Physa* sp., *Helisoma* sp., *Catinella vagans* (Pilsbry) and other species of *Oxyloma*, they did not lay eggs on living or dead snails; and they oviposited on vegetation only when egg masses were not available. Females confined with males had a pre-oviposition period of 3–4 days. Before laying eggs, females exhibited a curious behavior that apparently was a prerequisite for oviposition. They first searched the bottom of the breeding jar for a suitable oviposition site (i.e., snail egg masses). Upon locating a mass, the female would walk onto it and spend several minutes exploring its surface with her front tarsi. After this brief routine she would begin laying eggs. Eggs were scattered over the surface of the masses, with 1–30 eggs deposited on each egg mass in the laboratory. Eggs deposited on *Oxyloma* sp. egg masses were so oriented that the upturned anterior and posterior ends projected above the surface of the egg mass. Soon after the eggs were laid they appeared to be encircled by a colorless liquid which gave the appearance of a small halo around each egg. Eggs that were placed onto egg masses of other snail species did not show this phenomenon. Several females each laid over 150 eggs within 40 days, and one adult deposited 207 eggs within a 35-day period. Hatching occurred within 24–36 hours.

After hatching, each first-stage larva penetrated the egg mass and began attacking the contained eggs. Because of the viscosity of the gelatinous matrix surrounding *Oxyloma* eggs and the position of the eggs within the matrix, it was necessary for the larva to expend considerable energy and time in locating individual eggs. The larva traveled through the matrix in an undulatory manner. After a larva located an egg it began rasping at the vitelline membrane with its mouthhooks. After puncturing the membrane, the larva extended its anterior end into the egg and began feeding on the developing snail embryo. First-stage larvae occasionally entered the egg cell completely, in the process of ingesting its contents. A larva consumed the contents of one egg in a few hours then crawled through the



Figs. 1–8. *Antichaeta borealis*, immature stages. 1. Anterior segments, third-stage larva; 2. Lateral view, third-stage larva; 3. Posterior spiracular disc, posterior view, first-stage larva; 4. Posterior spiracular disc, posterior view, second-stage larva; 5. Posterior spiracular disc, posterior view, third-stage larva; 6. Anterior spiracle, second-stage larva; 7. Anterior spiracle, third-stage larva; 8. Posterior spiracular plate, third-stage larva. Abbreviations: asp, anterior spiracle; csp, sclerotized sensillum; fh, float hair; mh, mouthhook; psp, posterior spiracle; ss, spiracular slit; va, ventral arch.

gelatinous matrix in search of other eggs. During this search for eggs and also during feeding, the posterior spiracles of the first-stage larva were frequently out of contact with the ambient air. The first stadium lasted 3–4 days, and by the 3rd day the larva had developed to such a size that the posterior spiracles could be extended above the surface of the egg mass. First-stage larvae in *Oxyloma* egg masses each consumed from 4–7 eggs. Molting took place within the egg mass.

First-stage larvae developing in *Physa* sp. and *Helisoma* sp. egg masses exhibited, for the most part, the same feeding behavior as those utilizing *Oxyloma* egg masses. Larvae in *Helisoma* egg masses fed on the underside of the mass (the side without a hardened protective covering). Relatively few of the first-stage larvae feeding on *Physa* sp. and *Helisoma* sp. egg masses reached the second instar.

Second-stage larvae remained in the *Oxyloma* egg masses and actively fed on the living snail embryos. Although second instars were restricted primarily to feeding on snail eggs, one larva that had not fed for 24 hours was observed to kill and eat a recently hatched *Oxyloma* snail. When several eggs had been laid on one egg mass and the larvae subsequently became crowded, several left the original egg mass and searched for others. Second-stage larvae fed with the posterior spiracles in contact with the surface of the egg mass. The second stadium lasted 2–3 days. By the 3rd day most of the larvae had acquired a faint red color in their digestive tracts, and their Malpighian tubules were dark maroon. The reddish coloring in the gut persisted during feeding and molting but disappeared when the larva defecated. The number of *Oxyloma* eggs consumed by each second-stage larva varied from 3–11, the usual number being 7. Like the preceding instar, molting took place within the egg mass. Second-stage larvae feeding on *Physa* and *Helisoma* egg masses failed to develop fully and died before the end of the second stadium.

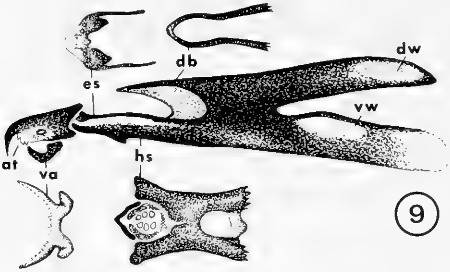
Third-stage larvae continued to feed on eggs within the masses. The reddish color of the intestine and Malpighian tubules became more pronounced, and the tracheal system became dark gray. During the 7–10 days of the third stadium, a larva consumed considerably more eggs than the other 2 instars combined. It was not unusual for a third instar to destroy 105–110 *Oxyloma* eggs.

When third-stage larvae became fully developed, they stopped feeding, frequently abandoned the egg mass and burrowed into the cotton or moist filter paper in the rearing dishes where pupariation occurred. Hardening of the puparium required about 5 hours. The prepupal period lasted approximately 1 day; the pupal period, about 15 days.

The earliest collection record for adults in northeastern Ohio was 16 May (1965); the latest, 10 December (1965). Adult populations peaked around the end of June or the first part of July. Larvae and pupae were discovered in nature between May and September. *Antichaeta borealis* is multivoltine and overwinters as diapausing pupae. In northeastern Ohio first-generation adults emerged in early May.

Puparia collected in January (1966) and retained at temperatures between 5–7°C for at least 60 days produced adults after 8–10 days after being returned to room temperature. Adult males were usually the first to emerge and were followed by females in 24–48 hours. Reared adults lived 7–44 days. Field collected adults lived 3–36 days in the laboratory.

Three species of Ichneumonidae, *Phygadeuon* sp. A, *Phygadeuon* sp. B and *Mesoleptus* sp. (determined by Dr. William Mason) were reared from puparia collected in marshes near Kent. Each infested puparium produced only 1 wasp.



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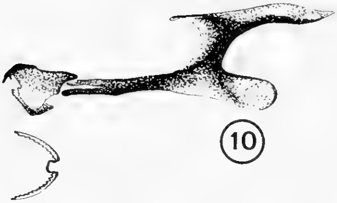

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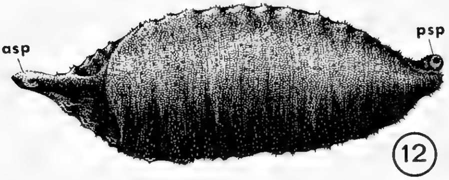

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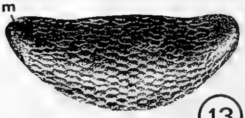

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Figs. 9–13. *Antichaeta borealis*, immature stages. 9. Cephalopharyngeal skeleton, third-stage larva; 10. Cephalopharyngeal skeleton, first-stage larva; 11. Cephalopharyngeal skeleton, second-stage larva; 12. Lateral view, puparium; 13. Lateral view, egg. Abbreviations: asp, anterior spiracle; at, accessory teeth; db, dorsal bridge; dw, dorsal window; es, epistomal sclerite; hs, hypostomal sclerite; m, mycropyle; psp, posterior spiracle; va, ventral arch; vw, ventral window.

Description of Immature Stages

Egg (Fig. 13).—Length 0.62–0.71 mm, greatest width 0.21–0.24 mm. White. Elongate-ovoid, ventral surface more curved than dorsal surface. Micropylar end slightly truncate (in dorsal view), posterior end rounded. Contents of egg white, developing embryo yellowish white. Chorion distinctly reticulated, with 4- to 7-sided cells. Posterior end without reticulations.

First-stage larva (Figs. 3, 10).—Length 1.10–2.16 mm, greatest width 0.32–0.51 mm. Translucent. Integument slightly papillose, not pubescent. Metapneustic. Posterior spiracular disc (Fig. 3) at apex of elongate postanal portion of segment 12; disc with 2 pairs of weak, rounded lobes (ventrolateral lobes slightly larger than ventrals) and 2 spiracular plates, each with 2 spiracular slits. Postoral spine patch reduced to a few rows of dark spinules around anterior margin of segment. Dorsal patches on segments 6–11 reduced to few scattered spinules. Venters of segments 6–11 with a few dark spinules on anterior creeping welt; middle and posterior creeping welts with patch of dark spinules, 4–6 spinules wide; spinules few or lacking laterally. Anterior portion of segment 12 ringlike, bearing continuous band of dark spinules; postanal portion greatly extended dorsally. Perianal pad transverse, lobes enlarged. Cephalopharyngeal skeleton (Fig. 10) lightly pigmented, length 0.18–0.23 mm, indentation index approximately 66. Mouthhooks lightly pigmented, triangular with 2 small openings dorsally; darkly pigmented bifid hooks on anterodorsal margin; no accessory teeth. Ventral arch (Fig. 10) curved with 14–16 teeth. Cornua of pharyngeal sclerite without distinct openings; dorsal cornu ⅓ longer than ventral cornu. (Based on 10 larvae.)

Second-stage larva (Figs. 4, 6, 11).—Length 1.87–2.74 mm, greatest width 0.58–0.74 mm. Unicolorous white. Integument papillose, slightly pubescent. Anterior spiracles (Fig. 6) rounded, with 20–23 marginal papillae; papillae close together and not as elongate as those of 3rd instar. Posterior spiracular disc (Fig. 4) bearing 2 spiracular plates each with 3 spiracular slits and 4 branching, hairlike, interspiracular processes. Spinule distribution similar to that of 1st instar. Sparse patch of dark spinules on anterior creeping welt on venters of segments 6–11 reduced to small patch along meson. Cephalopharyngeal skeleton (Fig. 11) pigmented, length 0.31–0.46 mm, indentation index approximately 55. Mouthhooks deeply pigmented, each with single, lightly pigmented accessory tooth. Ventral arch with winged process laterally; anterior margin with 16–18 variously sized teeth. Ventral cornua slightly longer than dorsal cornua, both with unpigmented windows posteriorly. (Based on 10 larvae.)

Third-stage larva (Figs. 1, 2, 5, 7, 8, 9).—Length 3.60–5.51 mm, greatest width 0.77–1.10 mm. Yellowish tan. Integument papillose, appearing pubescent due to dense covering of small, 0.04–0.06 mm spinules. Body elongate, subcylindrical, tapering anteriorly, somewhat truncate posteriorly. Segment 1 weakly bilobed apically (in dorsal view), each lobe bearing lightly sclerotized sensillum (csp) anterodorsally; postoral segment bearing spine patch posteriorly, with band extending halfway-up on each side of segment (Fig. 1). Anterior spiracles tan, (Fig. 7) dorsolateral on posterior margin of segment 2, subcircular with 22–23 marginal papillae; outer lateral surface of each papilla with small, irregular, clear area. Posterior spiracles at tip of elongate stigmatic tubes on posterior spiracular disc. Spiracular disc (Fig. 5) with 2 pairs of weak lobes; ventrolateral lobes somewhat larger than ventrals; 2 spiracular plates (Fig. 8), each with 3 elongate spiracular slits and dark stigmatic scar; 4 transparent, branched interspiracular processes or float hairs on each plate. Segments 3–11 with numerous transparent spinules; segments 1 and 2 without spinules. Each segment (3–11) divided ventrally and dorsally by secondary integumentary folds to form anterior, middle and posterior welts. Segment 3 with row of dark spinules on anterodorsal margin, venter of segment with sparse spinule band anteriorly. Segment 4 without dark spinules dorsally; venter of segment with sparse spinule band, 3–4 spinules wide, on anterior margin. Segments 5–6 with band of a few dark spinules on anterior and middle welts. Segments 6–11 without distinct dark spinules dorsally or ventrally. Segment 12 with a few pre-anal spinules, located along meson. Perianal pad bilobed, anus longitudinal on mid-line. Cephalopharyngeal skeleton (Fig. 9) deeply pigmented, length 0.77–0.79 mm, indentation index approximately 51. Mouthhooks (in dorsal view) converging anteriorly, separated posteriorly; 3 lightly pigmented accessory teeth (at) beneath each hook part. Anterior margin of ventral arch (va) with 22–23 anteriorly directed, variously sized teeth. Epistomal sclerite (es) fused to parastomal bars of pharyngeal sclerite. Pharyngeal sclerite with dorsal and ventral cornu separated by sinus extending slightly more than halfway to anterior edge of sclerite, ventral cornua with elongate window (vw), dorsal cornua with small, tapering window (dw); narrow parastomal bars arising from anterior margin of sclerite. (Based on 10 larvae.)

Puparium (Fig. 12).—Length 3.71–4.82 mm, greatest width 1.70–2.12 mm. Dark brown. Elongate, subcylindrical, anterior end flattened dorsoventrally, posterior end tapered. Ventral surface slightly more flattened than dorsal. Integument dull, opaque, with pubescent appearance due to tanned spinules of 3rd instar. Intersegmental and secondary intrasegmental folds distinct. Segment 1 invaginated. Anterior spiracles (asp) tan, fan-shaped. Postanal portion of segment 12 narrower than pre-anal portion: Perianal pad bare; lobes on posterior spiracular disc reduced; stigmatic tubes uplifted and divergent; spiracular plates yellow. (Based on 10 puparia.)

Discussion

Information available on the studied species of *Antichaeta* indicates that the species segregate primarily by habitat and species of food utilized. In North America, *A. testacea* Melander and *A. borealis* are commonly found in permanent marshes and are associated with snails that produce eggs more or less continuously throughout the year. Both of these species of *Antichaeta* are multivoltine. The habitats of *A. melanosoma* Melander are vernal pools, temporary woodland pools and areas in large marshes where there is a seasonal drop in water level. In such habitats the host snail, *Aplexa hypnorum* (L.), is most active at 1 or 2 times a year. As might be expected, this species is univoltine (Knutson and Abercrombie, 1977).

The 4 European species, A. *analis* (Meigen), A. *atriseta* (Loew), A. *obliviosa* Enderlein and A. *brevipennis* (Zetterstedt), all seem to be associated with vernal marshes (Knutson, 1966).

A wide variety of foods is utilized by different *Antichaeta* species. According to Fisher and Orth (1964), first- and second-stage larvae of A. *testacea* can feed on the eggs of several snail species, including those of *Oxyloma*, *Physa*, *Succinea*, *Radix*, *Stagnicola*, *Pseudosuccinea* and *Helisoma*. Third-stage larvae continue to feed on snail eggs but also can kill and eat juvenile and adult snails. Larvae of A. *testacea* show the most generalized feeding habits of all the studied species of *Antichaeta*. In the laboratory, first- and second-stage larvae of A. *melanosoma* and A. *borealis* feed on the eggs of several species of snails, but unlike A. *testacea*, the larvae failed to continue development on eggs other than those of the host species. Third-stage larvae of A. *melanosoma* killed and ate adult snails of the host species (Knutson and Abercrombie, 1977), but third-stage A. *borealis* larvae limited their feeding to *Oxyloma* eggs and refused juvenile or adult snails. Under laboratory conditions larvae of A. *analis* and A. *brevipennis* fed on eggs of *Lymnaea* and *Succinea* snails, but neither attacked juvenile or adult snails.

In areas where species overlap in habitat distribution, they are segregated by differential food utilization. For example, in northeastern Ohio, 3 species of *Antichaeta*, A. *borealis*, A. *fulva* Steyskal, and A. *melanosoma*, occur in the same marsh habitats at approximately the same time of year (late April–June). The first species utilizes *Oxyloma* eggs; the second, *Lymnaea* sp. eggs; and the third, eggs of *Aplexa* and *Physa*. There may be some slight habitat segregation (especially with A. *melanosoma*) among the 3 species, but it does not seem to be as significant an isolating factor as the differences in food utilization.

Acknowledgments

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(WHR) Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061; and (BAF) Department of Biological Sciences, Kent State University, Kent, Ohio 44242.

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MORNING GLORY BEES AND THE *IPOMOEA PANDURATA* COMPLEX (HYMENOPTERA: ANTHOPHORIDAE)

Daniel F. Austin

Abstract.—Oligolectic bees and their association with *Ipomoea pandurata* and its allied species were studied in North America. *Cemolobus ipomoeae* was found to be closely related to *Ipomoea pandurata*; *Melitoma grisella* has been shown to be linked with *Ipomoea leptophylla*; *Ptilothrix sumichrasti* was found with *Ipomoea longifolia*. The exact relationships between each bee species and each plant species are different.

According to the literature three bee genera in the Anthophoridae, *Ancyloscelis*, *Cemolobus* and *Melitoma*, are oligolectic to the genus *Ipomoea* (Michener *in* Muesebeck et al., 1951; Michener, 1954). Two of these, *Cemolobus* and *Melitoma*, occur in the eastern United States. Moreover, Robertson (1929) suggested that these bees were probably associated with *Ipomoea pandurata* (L.) Meyer, one of the few endemic species of *Ipomoea* in the eastern United States. My study began in the summer of 1971 largely as an attempt to confirm the existence of close relationships between these bees and plants. Once oligolecty[1] was documented, the following two summers were used for field study of widely separated populations of *I. pandurata*. Patterns of insect behavior at the flowers were found to be essentially constant throughout the range of bees and plants.

Materials and Methods

Field studies were made in Florida, Georgia, South Carolina, North Carolina, Virginia, Pennsylvania, Ohio, Indiana, West Virginia, Illinois, Missouri, Kentucky and Tennessee. In addition to the field studies, herbarium material of *Ipomoea* has been examined in A, FAU, FLAS, GH, UNC, US, MO, and USF (abbreviations follow Lanjouw and Stafleu, 1959). The herbarium and field studies were augmented with various floras to provide accurate distributions (Britton & Brown, 1898; Small, 1903, 1933; Wooten & Standley, 1915; Deam, 1940; Tidestrom & Kittell, 1941; Fernald, 1950; Kearney & Peebles, 1951, 1961; Jones et al., 1955; Mohlenbrock & Voight, 1959; Gleason & Cronquist, 1963; Steyermark, 1963; Justice & Bell, 1968; Radford et al., 1968; Conard, 1969; Correll & Johnston, 1970; Wharton & Barbour, 1971; Brown, 1972; Ellis & Chester, 1973). Insects were determined with the help of Paul D. Hurd, Jr., and several other members of the Entomology Department, Smithsonian Institution as well as Mitchell (1960, 1962).

Ipomoea pandurata, Intrafloral Ecology

Robertson (1891, 1925a, 1925b, 1928, 1929) reported a series of insect visitors to *I. pandurata.* Of these only two show oligolecty to these plants: *Cemolobus ipomoeae* Robertson and *Melitoma taurea* (Say).

Oligolectic bees.—While few studies have been made of the life history of the monotypic *Cemolobus* (Robertson, 1891, 1925a, 1925b), all past and present data indicate that it utilizes pollen only from *I. pandurata.*

Cemolobus is a matinal species, although cool, foggy, or rainy mornings may cause the bees to shift their activities later in the day. Under normal weather conditions the first bees arrive at *I. pandurata* flowers between 6:30 and 7:00 AM. For about the first two hours the majority of individuals visiting the flowers are females. Males arrive later and may remain active until 12:00 or 1:00 PM.

Females enter the flowers head-first to sip nectar; pollen is collected with the legs during this time. After nectar is taken they may either back out of the tube onto the inner edge of the limb to collect pollen with the front legs, or they may turn around within the tube facing out and collect pollen. Usually there is a shift from backing out early in the day to turning around within the tube later. On a few occasions these females were seen "drumming" with the wings while sitting on the inner edge of the limb and collecting pollen with the front legs. Pollen is transferred to the scopae of the posterior legs either while on the flower limb or in the air. These normally brown females are conspicuously white with pollen as they leave the plants to return to their nests.

The scopae of each female are capable of carrying large amounts of pollen and this requires the bees to visit several flowers before they are filled. Flights from flower to flower are rapid and direct. Although no male bees collect pollen it is common for them to visit several flowers and then to perch on the corolla limb or nearby plants to clean themselves of pollen.

When the flowers open the stigmas have no pollen on them, but grains are left on the stigma by each visit. Bagged or emasculated flowers or solitary plants on the fringe of the range that are not pollinated produce no fruits, while pollinated flowers fruit abundantly.

Melitoma taurea is a member of a small American genus of bees that is known to utilize only *Ipomoea* pollen in their nests (Michener *in* Muesebeck et al., 1951; Michener, 1954, 1975). The species *M. taurea* is not specific to a single species of *Ipomoea* in the eastern United States, but has been collected at the flowers of *I. sagittata* Lam. and *I. aquatica* Forsk. (Austin, unpublished), *I. purpurea* (L.) Roth (Robertson, 1929) and *Calystegia sepium* (L.) R. Brown (Robertson, 1891). Robertson indicated that the bees were only taking nectar from *Calystegia* and not collecting pollen.

Melitoma taurea is also a matinal bee, and females often appear at the flowers of *I. pandurata* before *Cemolobus.* As with *Cemolobus* females, visits to the plants begin between 6:30 and 7:00 AM. *Melitoma* enters the floral tube head-first to sip nectar. While doing this they actively brush pollen from the anthers with their legs. Unlike *Cemolobus*, they almost invariably turn around within the corolla tube to face outward. Once they have turned around they collect more pollen and transfer it to their scopae. When the scopae are full, the females leave the plants; they later return with empty scopae.

Melitoma uses the flowers of *I. pandurata* as trysting sites. Once the females have collected pollen for about two hours, the number of males visiting the plants increases markedly. Males enter flowers much less often than do females. The most common behavior is for the males to rapidly fly from flower to flower, pausing on the limb only long enough to determine if a female is inside the tube. If no female is present, the males rapidly visit other blossoms. Once a flower is found containing a female, the male enters and copulation occurs. About one flower visit in ten is used by the males to take nectar.

Other insects.—A series of insects has been recorded by Robertson (1891, 1925a, 1925b, 1928, 1929) as visitors to *I. pandurata*; my own collections include most of these. Several of these visitors are oligolectic bees with close pollen relationships to other plants, e.g. *Peponapis* and *Xenoglossa* to *Curcurbita* (Hurd et al., 1971). Most common among the other insects visiting *I. pandurata* is *Bombus.*

Bombus auricomus (Robertson), *B. griseocollis* (Degeer), *B. vagans* F. Smith and *B. pennsylvanicus* (Degeer) (Robertson, op. cit.) visit throughout the range of the plants. I found *B. pennsylvanicus* to be the predominate species. These bees are often found taking nectar when no other insects are active, particularly on foggy or drizzly mornings. *Bombus* spp. transfer pollen frequently although they have never been seen storing it in their scopae. They do often stop to clean pollen from their body and leg hairs. Members of this genus are the only visitors seen visiting the flowers on the extreme northern limits of *I. pandurata* range.

Cemolobus, *Melitoma* and *Bombus* are considered the primary pollinators of *I. pandurata* because they transfer pollen to the stigmas with each flower visit, and usually have two hours to visit flowers and transfer pollen before other visitors appear. Other visitors serve as occasional pollinators.

Ipomoea pandurata, Relatives and Other Bees

The closest relative of *I. pandurata* in the United States is *I. leptophylla* Torrey. Ranges of these two plants overlap in eastern Oklahoma and northeastern Texas. In the area of overlap is a rare population, *I. shumardiana* (Torrey) Shinners. Robert Pearce has proposed that this population is the result of hybridization between *I. pandurata* and *I. leptophylla* (Shinners *in* Correll and Johnston, 1970).

Ipomoea leptophylla is a prairie species known to range from southeastern Montana south into Texas. This plant was studied by Linsley (1960) near Los Montoyas, New Mexico. Linsley found *Melitoma grisella* (Cockerell and Porter), a matinal pollen collector, to be the major visitor and pollinator of this species. Three other genera of bees visit *I. leptophylla*, but their visits were for nectar only and no pollen was collected. *Melitoma grisella* is the only *Ipomoea* oligolege found in the northern part of the range of the plants.

In the small area of range overlap of *I. pandurata* and *I. leptophylla* in Oklahoma and Texas, there is also an overlap of *Melitoma taurea* and *M. grisella.* If hybridization is the origin for the plants named *I. shumardiana*, either of these bees or *Bombus* could be responsible for the crossing.

Ipomoea longifolia Bentham is known from two border counties in Arizona south to the state of Queretaro, Mexico. Linsley et al. (1956), Butler (1967) and Cazier and Linsley (1974) studied this species and found two oligolectic bees associated with the plants. Most closely allied with *I. longifolia* is the bee *Ptilothrix sumichrasti* (Cresson); also gathering pollen was *Melitoma segmentaria* (Fabricius) (= *Melitoma euglossoides* Lepeltier and Serville). Exhaustive study of the biology of this *Ptilothrix* indicates that the species is oligolectic to *I. longifolia* as long as the plant is flowering (Linsley et al., 1956; Linsley and MacSwain, 1958; Michener, 1974; Torchio, 1974). The *Ptilothrix* is not as species-specific as *Cemolobus* but takes pollen from other *Ipomoea* species when *I. longifolia* has finished its blooming season. *Ipomoea pringlei* Gray is the species noted to be visited by both *Ptilothrix* and *Melitoma* as the flowering season of *I. longifolia* ends.

Summary.—The data show that two species of bees have specific requirements for *Ipomoea* pollen in the eastern United States. *Cemolobus ipomoeae* is specific in pollen collecting habits and uses only *I. pandurata* pollen. Both the plants and the bees are endemic to the deciduous forest areas of the eastern United States. *Melitoma taurea* is found in the same region, but is less specific in pollen collecting as it takes pollen from several species of *Ipomoea.*

Related to *I. pandurata* is the prairie species *I. leptophylla.* Present data indicate that this plant is closely linked with *Melitoma grisella.* At present it is not possible to determine whether *I. shumardiana* is a hybrid between *I. pandurata* and *I. leptophylla.*

The closest relative to *I. leptophylla* and *I. pandurata* is the Arizonan and Mexican species *I. longifolia. Ptilothrix sumichrasti* is oligolectic to *I. longifolia,* however, the relationship is somewhat different from the other United States species. As long as *I. longifolia* is in flower, this *Ptilothrix* uses pollen only from that species. When this *Ipomoea* stops flowering, the bees shift to another species.

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Department of Biological Sciences, Florida Atlantic University, Boca Raton, Florida 33431.

Footnote

[1] Oligolectic, as used here, refers to bees whose females utilize pollen from one or a few species of plants as food for their young. This usage conforms to that by Robertson (1929), Michener (1954), Linsley & MacSwain (1958), Faegri and van der Pijl (1966) and Baker and Hurd (1968) among others. Some biologists object to such usage since it ignores adult male activities.

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A NEW STONEFLY FROM WEST VIRGINIA (PLECOPTERA: CHLOROPERLIDAE)

P. P. Harper and R. F. Kirchner

Abstract.—*Alloperla aracoma* is described from the Guyandotte River system in West Virginia; it is closely related to *Alloperla leonarda* Ricker. Both species are illustrated.

During an investigation of the stonefly fauna of West Virginia, the junior author collected a series of specimens which at first appeared to be a form of *Alloperla leonarda* Ricker 1952; on closer examination of the male genitalia, however, it became apparent that the series represented a new species; its description follows.

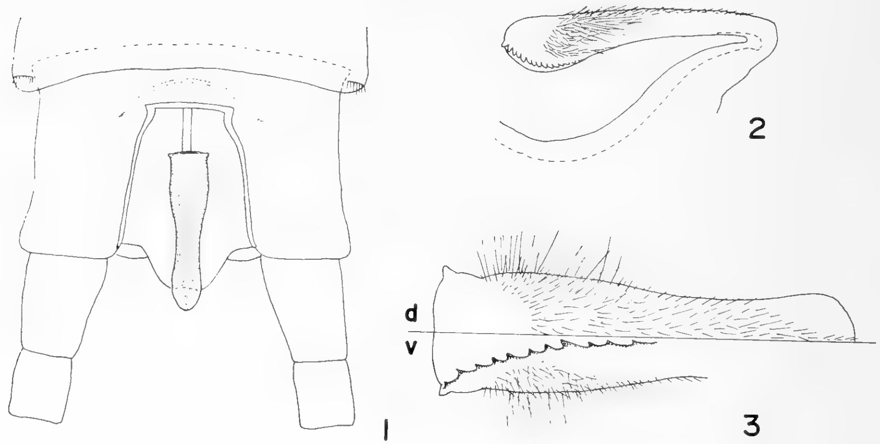
Alloperla aracoma Harper and Kirchner, new species
Figs. 1–3

Body length.—Six (♂) to 7.5 (♀) mm; wing length: 6.5–8 mm. General habitus similar to other *Alloperla*; color uniformly pale green (yellowish white in alcohol-preserved specimens), wings with a light greenish tinge; an obscure series of brownish marks on the mid-dorsum of abdominal terga 2–7, not forming a definite mid-dorsal stripe.

Male genitalia.—Genitalia resemble those of other *Alloperla*. Abdominal segments 8 and 9 with rows of dark spines on their lateral margins. Tergum 10 cleft with a median depression into which fits the epiproct. Epiproct fixed to the anterior border of tergum 10 by an anchor-like structure; it is prolonged posteriorly as a thin rod and produced as a forward directed process (Fig. 1); the process (Figs. 2 and 3) gradually expanded distally and its apex truncate with 2 lateral knobs; process covered dorsally and laterally with setae except at the tip and it bears on its ventral surface 2 rows of a dozen or so thorn-like spines; length of the process of the epiproct at least ⅔ that of basal rod.

Female genitalia.—Hind margin of the 8th abdominal sternum produced into triangular subgenital plate which is somewhat thickened in its middle; the plate is very similar to that described and illustrated by Baumann (1974) for *Alloperla imbecilla* (Say).

Holotype.—♂, West Virginia, Logan County, Holden, Frogtown Hollow of the Copperas Mine Fork of Island Creek in the Guyandotte River system; 7 May 1975; R. F. Kirchner. Allotype ♀, same data. Paratypes: 15♂, 4♀, 7 May 1975; 9♂, 15♀, 12 May 1975; 8♂, 1♀, 2 May 1976; 9♂, 15♀, 8–15 May 1976; 8♂, 10♀, 8 May 1977, all from Frogtown Hollow. One ♂, 2♀, West Virginia, Mingo County, Laurel Fork of Pigeon Creek; 30 May 1976; R. F. Kirchner and T. Mayberry Jr.



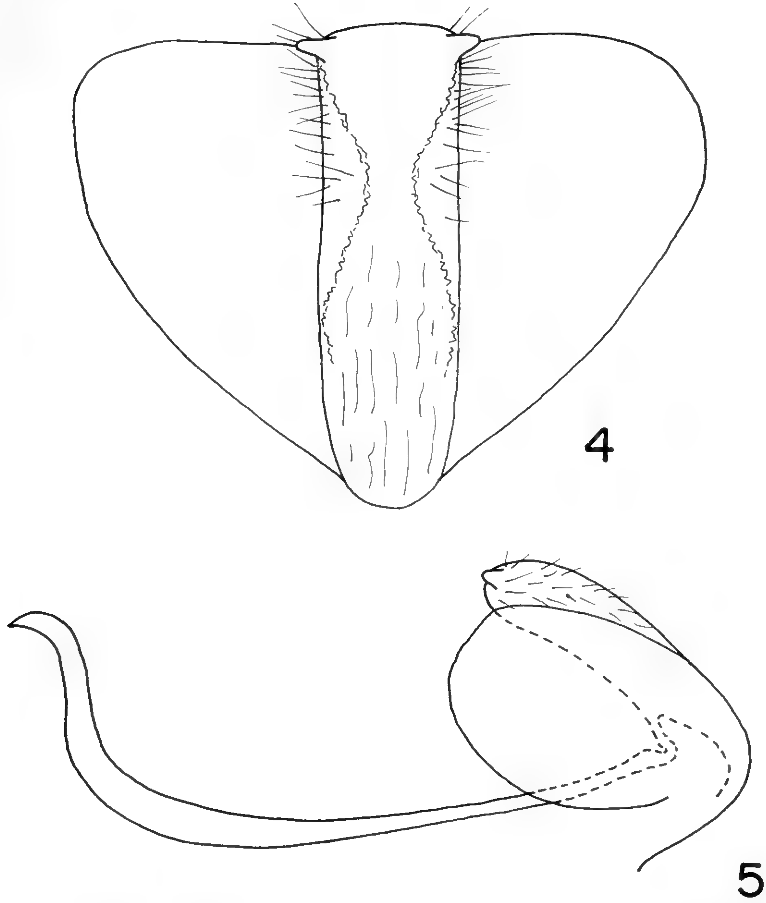
Figs. 1–3. Male genitalia of *Alloperla aracoma.* 1, dorsal view of terminal abdominal segments. 2, epiproct, side view. 3, process of epiproct, dorsal and ventral aspects.

The holotype and the allotype will be deposited in the U.S. National Museum. Paratypes will be in the USNM, the Entomological Collection of the Université de Montréal and in the authors' collections.

Derivation of the name.—From Princess Aracoma, daughter of Chief Cornstalk of the Shawnee Indians, who had a village on Middleburg Island on the Guyandotte River.

Type-locality.—Frogtown Hollow is an intermittent stream, 3–4 feet in width, at an elevation of 800–1,200 feet above sea level. Riparian vegetation includes yellow-poplar, American beech, sugar and red maples, black birch, yellow buckeye, hemlock, cucumber and umbrella magnolias, white ash, red oak, shagbark hickory, spicebush, wild hydrangea, witch hazel and hornbean. Associate Chloroperlidae are *Hastaperla brevis* (Banks), *Alloperla imbecilla* (Say), *Alloperla usa* Ricker and *Sweltsa mediana* (Needham & Claassen).

Diagnosis.—The male of *Alloperla aracoma* bears much superficial resemblance to *A. leonarda* (see Ricker, 1952, Fig. 132 and Harden and Mickel, 1952, Pl. X, Figs. 7–8 as *A. sylvia*). The distinguishing features are the following: In *A. aracoma* the process of the epiproct is long, about ⅔ as long as the basal rod (Fig. 1); in *A. leonarda* the process is less than ½ as long as the rod (Fig. 5). Though both species bear lateral knobs on the tip of their epiproct (Figs. 3 and 4), the shapes of the processes are markedly different, and only *A. aracoma* possesses the rows of ventral spines (Figs. 2 and 3). Furthermore only *A. leonarda* has large fleshy lobes



Figs. 4–5. Male genitalia of *Alloperla leonarda*. 4, process of epiproct, dorsal aspect. 5, epiproct, side view.

adjacent to the lobes of the epiproct (Fig. 4). In Hitchcock's (1974) key to the northeastern species of *Alloperla* (s. l.), the female of *A. aracoma* will key out to *A. imbecilla* from which it can be distinguished at present only by its smaller size; *A. atlantica* Baumann, a species long confused with *A. imbecilla*, will also key there and again the smaller size of *A. aracoma* will be the main diagnostic feature.

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(PPH) Département de Sciences biologiques, Université de Montréal, C.P. 6128, Succursale "A," Montréal, Québec H3C 3J7, Canada; and (RFK) Rt. 1, Box 412-A, Barboursville, West Virginia 25504.

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TAXONOMY AND DESCRIPTION OF TWO PRIONINE CERAMBYCIDAE FROM SOUTHERN ARIZONA: A NEW SPECIES OF *STENODONTES* AND NEW STATUS FOR *NEOMALLODON ARIZONICUS* (COLEOPTERA)

Durward D. Skiles

Abstract.—Recent studies of the prionine Cerambycidae of southern Arizona have revealed two new forms, a new species, *Stenodontes* (*Mallodon*) *madericus*, and the previously unrecognized male of *Stenodontes* (*Neomallodon*) *arizonicus* (Casey). Both species inhabit oak woodlands from central Arizona to northwestern Mexico and the larvae infest the heartwood of living evergreen oak trees. Discovery of these new forms necessitates revisions of Linsley's (1962) keys to the North American genera of the prionine tribe Macrotomini and the North American species of the genus *Stenodontes*. Clearly generically distinct from other Mexican and North American Macrotomini, *S. arizonicus* is redescribed and the subgenus *Neomallodon* Linsley is elevated to generic status.

Recent studies of the southern Arizona prionine Cerambycidae presently assigned to the genus *Stenodontes* (Linsley, 1962) have revealed two previously unrecognized forms, a new species described below as *Stenodontes* (*Mallodon*) *madericus*, and the heretofore unknown male of *Stenodontes* (*Neomallodon*) *arizonicus* (Casey).

Although infrequently collected, *S. madericus* ranges from north central Arizona to northwestern Mexico and can be found among other species of Macrotomini in almost any large collection of southern Arizona Cerambycidae. It is indeed remarkable that this distinctive prionine has remained undescribed for so long, but the small number of specimens collected prior to the last few years and the similarity of habitus of the females and minor males of the western species of *Stenodontes* are undoubtedly responsible. As a case in point, the author identified his first specimens of *S. madericus* as females of *S. lobigenis* (Bates), and it was not until the holotype male was collected that it was clear a distinct species was at hand. Realization that the species was undescribed was further delayed by the fact that the strong, basally retracted mandibles suggested that the specimen was a male of *S. arizonicus*.

The latter species, originally described over sixty years ago (Casey, 1912), remains rare in collections despite the fact that collecting has persisted within its range for almost a century. Less than ten specimens of *S. arizonicus* were known to Linsley (1962) when he revised *Stenodontes*. The lack of material, the short mandibles, and the rather similar appearance of the sexes led Linsley to include only the female in his revision, although Linsley et al. (1961) refer to a male taken in Cave Creek Canyon in the Chiricahua Mountains of southeastern Arizona. The latter specimen, however, was known only to Knull (Linsley, personal communication).

Intensive collecting in southern Arizona by several individuals in recent years has enabled the author to examine a substantial series of S. *arizonicus* and, thereby, to distinguish the male and female and to significantly extend the known range of the species. A revised description of the species is presented below, and on the basis of the rather subdued sexual dimorphism and other obvious structural differences from all closely related taxa, it is proposed that the monotypic subgenus *Neomallodon* Linsley be elevated to generic status.

Description of these new forms necessitates revisions of Linsley's (1962) keys to the North American genera of the prionine tribe Macrotomini and the North American species of the genus *Stenodontes*. To ensure proper separation of the taxa and to remove the confusion of species almost invariably encountered in collections, the keys and descriptions are rather detailed. Because all but one species (*S. chevrolati* Gahan) of the North American Macrotomini occur in Mexico[1], and since Linsley (1934) originally described *Neomallodon arizonicus* (Casey) as *Aplagiognathus remotus* Linsley, the Mexican genus *Aplagiognathus* is included in the key to the Macrotomini.

Key to the North American Genera of Macrotomini

1\. Antenna with 3rd segment shorter than scape; scutellum concave 2

– Antenna with 3rd segment longer than scape; scutellum very convex *Strongylaspis*

2(1). Antennal tubercle obtuse; mandible nearly vertical, almost glabrous, neither carinate nor tuberculate above, prominently unidentate internally at about middle, not excavated internally; lateral margin of pronotum crenulate or denticulate, never spinose *Archodontes*

– Antennal tubercle obtuse or acute; mandible only moderately deflexed or nearly horizontal, basal ½ in profile tumid or broadly triangular above, or more or less carinate above and excavated internally, usually bi- or tridentate internally; lateral margin of pronotum denticulate to prominently spinose 3

3(2). Sexual dimorphism evident but rather subdued; mandible shorter than head, either robust or extremely short, dorsal and/or outer margin strongly retracted at base (except occasional females), always possessing numerous long setae on external margin; submentum unsculptured, broadly, shallowly, transversely impressed, usually finely to moderately, transversely rugose, occasionally polished and shallowly punctate; metepisternum broad 4

– Sexual dimorphism pronounced; mandible usually neither robust nor strongly retracted at base, in males as long or longer than head (except some minor males); if mandible strongly retracted at base, metepisternum narrow; submentum not as above, coarsely granulate-punctate and/or coarsely, usually longitudinally, rugose, posterior and anterior regions distinctly contrasting, anterior region usually recessed, occasionally only more finely punctate; metepisternum broad or narrow *Stenodontes*

4(3). Mandible in profile evenly arcuate dorsally, rather carinate above, distinctly excavated internally, a stout, broadly emarginate tooth before apex; antennal tubercle acute or scarcely obtuse; pronotum with lateral region obsoletely punctate, lateral margin denticulate, distinctly reflexed; metepisternum broad, inner margin straight or feebly convex *Neomallodon*

– Mandible in profile with basal ½ tumid or subtriangular dorsally, not or scarcely excavated internally, a strong, broadly rounded tooth before apex; antennal tubercle obtuse; pronotum with lateral region densely granulate-punctate, lateral margin spinose, not reflexed; metepisternum very broad, inner margin distinctly convex *Aplagiognathus*

Genus *Neomallodon* Linsley, NEW STATUS

Stenodontes (*Neomallodon*) Linsley, 1957:2; Linsley, 1962:18.

Sexual dimorphism not pronounced. Body large, robust, rather depressed. Head well developed; antenna robust, attaining basal ⅓ of elytron, scape longer than 3rd segment, 3rd segment robust, subequal to 4th; antennal tubercle acute or scarcely obtuse; mandible deflexed, robust, distinctly shorter than head, in profile rather evenly arcuate above, excavated internally, a stout, broadly emarginate tooth at apical ⅓, outer margin strongly retracted at base; submentum shallowly, transversely impressed. Pronotum very transverse, disk polished, almost impunctate, lateral margins reflexed, parallel in male, converging anteriorly in female; metepisternum broad, inner margin straight or feebly convex; elytral apices rounded, sutural angle rounded or subangulate.

Type-species.—*Paramallus arizonicus* Casey (by original designation).

Range.—Southeastern Arizona, and presumably northwestern Mexico.

Neomallodon arizonicus (Casey), NEW STATUS

Figs. 1, 2

Paramallus arizonicus Casey, 1912:228.

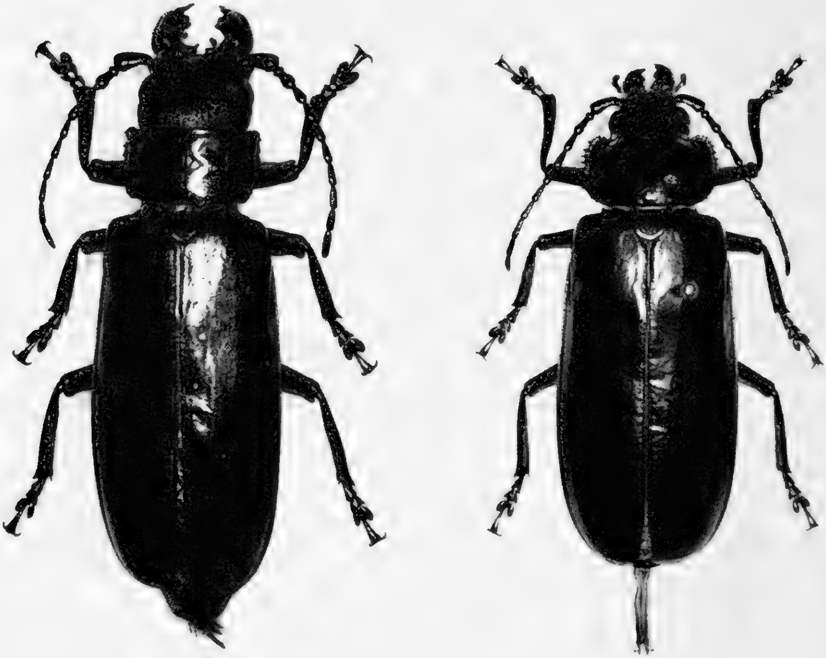

Fig. 1. *Neomallodon arizonicus* (Casey). Left, male; right, female. To afford a full view of the mandibles, the heads are only slightly deflexed.

Aplagiognathus remotus Linsley, 1934:161.
Stenodontes (*Neomallodon*) *arizonicus* (Casey), Linsley, 1957:3 (synonymy of *P. arizonicus* and *A. remotus*); Linsley, 1962:19; Linsley et al., 1961:3 (record).

Male.—Form elongate-robust, sides subparallel. Integument shining, glabrous, medium to dark red brown. Head deflexed, bisected by a longitudinal groove, fine basally, becoming broader and deeper on frons, abruptly bifurcating to form clypeal suture; dorsum coarsely, moderately to densely punctate, punctures usually less dense in broad median region extending from occiput to frons; antennal tubercle acute or scarcely obtuse; antenna attaining basal ⅓ of elytron, rather sparsely punctate, flagellar segments carinulate, basal segments distinctly broader than apical segments, 2nd segment transverse, 3rd ⅔ as long as scape, subequal to

4th and 5th, thence to 10th scarcely increasing in length, 11th distinctly longer than 10th, shorter than scape; mandible deflexed about 45°, tumid, very robust, distinctly shorter than head, above broadly carinate and rather evenly arcuate in profile, excavated internally with a stout, broadly emarginate tooth at apical ⅓ and a strong tooth at base, outer margin arcuate, strongly retracted at base, shallowly, sparsely punctate, a recurved seta arising from each puncture, inner margin more densely punctate, pubescence erect; submentum shallowly, transversely impressed, rather finely, transversely rugose; genal process broadly emarginate, subangulate below, rounded above. Pronotum shining, twice as broad as long, narrower than base of elytra, anterior margin broadly sinuate or feebly trisinuate, basal margin bisinuate, lateral margins subparallel, denticulate, distinctly reflexed; disk polished, impunctate or very finely, sparsely punctate, lateral regions vaguely rugose, punctures, large, shallow, obsolete except near disk; prosternum feebly impressed, very finely, sparsely punctate in front of coxae, finely to moderately rugose anteriorly, pubescence sparse, erect; metepisternum rather broad, finely punctate, inner margin straight or feebly convex; mesosternum, metasternum, and metepisternum covered with long, dense, erect, golden pubescence; scutellum broadly rounded, glabrous, nearly impunctate. Elytron 4.4–4.6 times as long as basal width, widest at or behind middle; surface shining, finely, sparsely punctate basally, more densely and vaguely so apically; apices separately, broadly rounded, suture rounded or subangulate. Legs short; femora shining, impunctate, with few scattered setae; tibiae sparsely pubescent, 2 thin lines of dense, golden pile on lower margins, punctures sparse, large, vague. Abdomen shining, glabrous beneath, thinly pubescent laterally, densely pubescent on lateral margins, 5th sternum densely fringed with long, golden setae, broadly subtruncate, feebly emarginate, usually very transverse and shorter than 4th. Length, apex of elytron to base of mandible, 40–47 mm.

Female.—Head distinctly smaller than in male. Mandible shorter and less robust than in male, moderately retracted at base, internal teeth less pronounced, preapical tooth truncate or feebly emarginate. Lateral margins of pronotum converging anteriorly. Elytron 4.5–4.7 times as long as basal width. Fifth abdominal sternum less transverse than in male, apex rounded or subtruncate, often feebly emarginate at middle. Length, 37–47 mm.

Type-locality.—Of *arizonicus*, Arizona; of *remotus*, Mt. Washington, altitude 6,000 feet, Santa Cruz Co., near Nogales, Arizona.

Known range.—Oak woodlands of southeastern Arizona (Fig. 2).

Flight period.—Late June to late July.

Host.—*Quercus.*

Habits.—The habits of *Neomallodon arizonicus* remain poorly known, and specimens, particularly males, are rare in collections. Adults are occasionally attracted to light during the early hours of darkness, but their flight is also crepuscular, for I have taken a male from the porch of the Santa Rita Lodge in Madera Canyon, Arizona during the evening twilight. Although observations are not sufficient to permit a detailed comparison, the larval habits and host preferences of *N. arizonicus* are apparently rather similar to those of its sympatric relative *Stenodontes madericus*, as larvae of each species have been found working in the heartwood of a living evergreen oak tree.

The only host record for *Neomallodon arizonicus* has been provided by C. E. Langston, who reared several adults (only one of which I have seen) from oak (either *Quercus emoryi* Torrey, *Q. oblongifolia* Torrey or *Q. arizonicus* Sargent) collected at Texas Pass in the Dragoon Mountains, Cochise County, Arizona. The larvae were found mining the heartwood of a large, living limb which had been seriously weakened by their extensive work. Living wood, however, is apparently not essential to larval development, since adults emerged from the limb over a period of two or three years. Moreover, in the trunks and larger limbs of dead oak trees in southeastern Arizona one occasionally finds extremely large emergence holes which are probably those of *Neomallodon arizonicus*. The holes are much larger than those characteristic of *Stenodontes madericus*, and are not readily attributed to *Prionus californicus* Motschulsky or *P. heroicus* Semenov, the only other sufficiently large cerambycids which are known or presumed to infest oak trunks in southeastern Arizona. Like many other members of the genus *Prionus*, *P. californicus* feeds primarily on the roots of living trees and pupates in the soil, and only occasionally feeds and pupates in dead logs or stumps (Linsley, 1962). The larval habits of *P. heroicus* have not been determined, but they are probably similar to those of *P. californicus*, since females have been found in leaf litter at the bases of both living oak trees (D. Skiles) and oak stumps (Hovore and Giesbert, 1976).

Diagnosis.—This species has clear affinities with both *Archodontes* and *Aplagiognathus*. Casey (1912) erected the genus *Paramallus* to include both his new species *P. arizonicus* and what is now known (Linsley, 1962) as *Archodontes melanopus* (L.). The distinctly deflexed head, rather stout, externally arcuate mandibles, plane, unsculptured submentum, broad metepisternum, and general facies of the pronotum indeed give the females of *Neomallodon* a very archodontine appearance, and I have often found the two species confused in collections. However, as Linsley (1957, 1962) recognized, *Neomallodon* is readily generically separated from *Archodontes* by the rather flattened body, acute antennal tubercles and basally retracted, internally excavated, bidentate mandibles.

Linsley (1934) originally placed his species *remotus* in *Aplagiognathus*, but upon examining the type of *Paramallus arizonicus* Casey, concluded that the two species were identical and placed them in synonymy in a new stenodontine subgenus, *Neomallodon* (Linsley, 1957). Unfortunately, Linsley was unable to examine the types side by side (Linsley, personal communication), and the rather subdued sexual dimorphism—the sexual dimorphism apparent in Fig. 1 is extreme for the species, the female being minor, the male very major—coupled with the fact that the Casey type is a large, robust, but obviously female, specimen, led him to conclude that the type and paratype of *Aplagiognathus remotus* were also female. The acute antennal tubercles and internally excavated and dorsally carinate mandibles then seemed to place the species in *Stenodontes*.

I have examined the genitalia of both the Casey type and the Linsley type and paratype. The former is female, and the latter, as originally stated by Linsley (1934), are male. The stout, basally retracted mandibles, unsculptured submentum and minimal sexual dimorphism indicate that *Neomallodon* is quite distinct from *Stenodontes* and more closely related to *Aplagiognathus*. From the latter, however, *Neomallodon* is distinguished by the dorsally arcuate, internally excavated mandibles, the acute antennal tubercles, and the distinctive structure of the pronotum.

Material examined.—Arizona. Holotype ♀ of *Paramallus arizonicus* Casey (USNM type 36405. No collection data with specimen. Casey (1912) gives the locality and collector as "Arizona-Levette."); holotype ♂ (CAS type 3822) and paratype ♂ (CAS) of *Aplagiognathus remotus* Linsley, Mt. Washington, near Nogales, Santa Cruz Co., alt. 6,000 ft., VII-20-1919 (J. A. Kusche). Santa Cruz Co.: Sycamore Canyon, 12 mi SE Ruby, 1♀, VII-22-71 (D. G. Marqua); Nogales, 1♀, VII-10-57 (Stange and Harding); Madera Canyon, 1♂ (flying at evening twilight), VI-28–VII-4-73, 1♀ (at light), VII-15-75 (D. D. Skiles); 1♀, VII-3-66, 1♀, VII-23–24–71 (F. T. Hovore, at light); 1♀, VII-10-70, 1♀, VII-12-73 (E. F. Giesbert, at light); 1♂, VII-11-57, 2♂♂, VII-12-57 (Stange and Harding); 1♀, VII-19–25-57 (R. L. Westcott); 1♀, VII-22-65, 1♀, VII-8-71, 1♀, VII-19-71 (D. G. Marqua); 1♀, VII-16-72 (A. E. Lewis). Pima Co.: Madera Canyon, 1♀, VII-11-70 (E. F. Giesbert, drowned in creek); Molino Basin, NE Tucson, 1♀, VII-10-73 (D. G. Marqua, at light). Gila Co.: Sierra Ancha Mts., 1♂ (D. K. Duncan, labeled *Archodontes cilipes* Say). Cochise Co.: Southwestern Research Station, 5 mi SW Portal, 1♀, VII-20-71 (E. F. Giesbert, at light); 3.5 mi SW Portal, 1♀, VII-11-66 (R. G. Beard); Miller Canyon, Huachuca Mts., 1♀, VII-14-69 (A. E. Lewis); Texas Pass, 1♂, VI-1-73 (C. E. Langston, reared ex *Quercus*); Cochise Stronghold, Dragoon Mts., 1♀, VII-29-57 (C. W. O'Brien); 1♀, VII-18-77 (D. G. Marqua, at light). Santa Rita Mts., 1♀, VII-11-50 (J. G. Rozen). Additional Arizona localities known to me are: Cochise Co.: Huachuca Mts. and Miller Canyon, Huachuca Mts. (Linsley, 1962:19).

Key to North American Species and Subgenera of *Stenodontes*

1. Antennae not or scarcely surpassing middle of elytra in male, not attaining middle in female; mandible of male at most but little longer than head, distinctly pilose internally 2

– Antennae attaining at least apical ⅓ of elytra in male, middle in female; mandible of male narrow, usually very much longer than head, almost glabrous (*Stenodontes* s. str.) *chevrolati* Gahan

2(1). Metepisternum broad, inner margin straight or feebly convex; mandible without strong preapical tooth on inner margin (*Orthomallodon*) *dasytomus* (Say)

– Metepisternum narrow, inner margin slightly concave in female, strongly concave in male; mandible with a strong preapical tooth on inner margin (*Mallodon*) 3

3(2). Integument medium to dark red brown; mandible tumid and retracted at base, particularly in profile (Fig. 4), outer margin rather strongly, evenly arcuate from base to tip, never but slightly longer than head; lateral margin of pronotum finely spinose, the subbasal spine most prominent, often 2× or more as long as remaining spines; anterior ½ of submentum deeply recessed, recession not attaining lateral sutures; genae not produced over submentum, but lateral and usually basal portions of submentum distinctly produced over recession in males, scarcely so in females *madericus*, new species

– Integument very dark brown or piceous; mandible not tumid or retracted at base, outer margin straight or slightly arcuate over basal ⅔, then rather abruptly inflexed to tip, in males (except some minor males) distinctly longer than head; lateral margin of pronotum generally finely denticulate, subbasal dentule occasionally prominent, not spinose; anterior ½ or ⅓ of submentum deeply recessed over entire width; genae distinctly produced over recession in males, less so in females *lobigenis* (Bates)

Stenodontes madericus Skiles, new species

Figs. 2–6

Stenodontes arizonicus Hovore and Giesbert, (not Casey), 1976:350 (habits).

Male.—Form elongate, flattened, sides sub-parallel. Integument shining, glabrous, medium to dark red brown. Head very coarsely, rugosely punctate around eyes, punctures becoming sparse and separate in broad, polished median region extending from occiput to frons and continuing laterally onto antennal tubercle; dorsum with a longitudinal impression, very fine basally, becoming broad and deep on frons, abruptly bifurcating to form

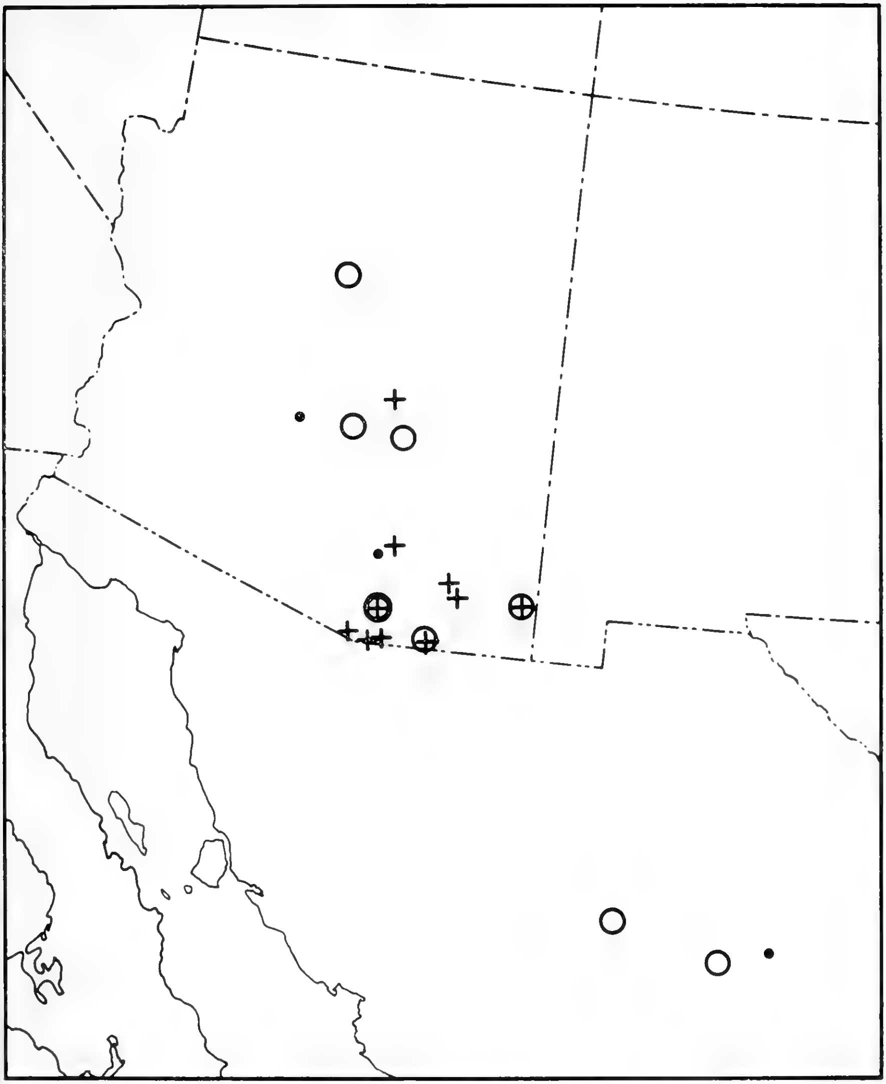

Fig. 2. Known geographical ranges of: *Neomallodon arizonicus* (Casey), +; *Stenodontes madericus* Skiles, ○. Heavy circle indicates the type locality of *S. madericus*. Small solid dots show the locations of the cities of Phoenix, Tucson, Chihuahua.

clypeal suture; occiput finely granulate-punctate, a few punctures extending onto vertex; antennal tubercle acute; antenna attaining middle of elytron, scape coarsely, closely punctate externally, pedicel and basal flagellar segments finely, sparsely punctate, segments beginning with

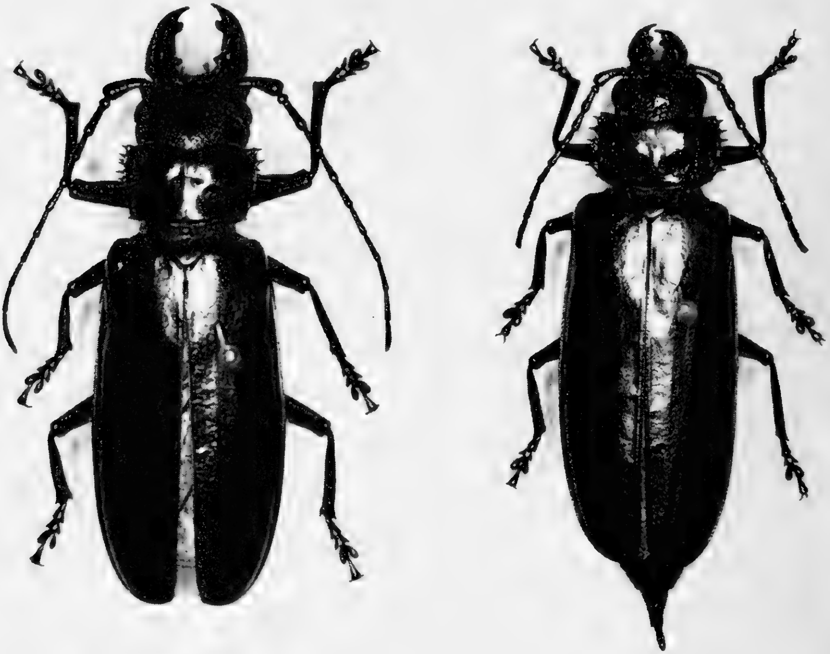

Fig. 3. *Stenodontes madericus* Skiles. Left, holotype male; right, allotype female.

3rd or 4th carinulate externally, carinulae becoming more numerous distally, apical segments completely carinulate, 3rd segment shorter than scape, longer than 4th, 5th through 10th subequal or gradually increasing in length, 11th distinctly longer than 10th, subequal to scape, feebly appendiculate; mandible longer than head, tumid, strongly retracted at base, basal ½ bulbous in profile, subangulate above, about 3× as thick as base of apical ½, abruptly declivous at middle of mandible; outer margin coarsely, densely punctate, a long recurved seta arising from each puncture, inner margin more densely punctate, setae very long, erect, a strong blunt tooth before apex, a strong triangulate tooth at or before middle; submentum coarsely, rugosely punctate, anterior ½ deeply recessed, recession not attaining lateral suture, sides and base distinctly, usually dramatically, produced over recession, genal-submental suture carinate, not produced. Pronotum 2× as wide as long, anterior margin broadly trisinuate, basal margin broadly bisinuate, often with a 3rd vague sinus at middle, lateral margin finely spinose, subbasal spine most prominent,

Fig. 4. Profile of male S. *madericus*, showing bulbous, basically retracted mandible.

usually 2× as long as others; disk polished, very finely, sparsely punctate, punctures becoming much coarser and denser on sides which are very broadly, longitudinally rugose, base of disk with 2 transverse, oval impressions clearly visible to the naked eye; prosternum densely, usually finely, punctate and thinly pubescent, sparsely punctate between coxae; metepisternum very narrow, finely, densely punctate and pubescent, inner margin strongly concave; mesosternum and metasternum covered with dense golden pile, except shining, rather sparsely pubescent midline region which is narrow basally and broadly flaring apically; scutellum glabrous, very finely, very sparsely punctate. Elytra at least 2× as long as basal width, widest at about middle, base wider than pronotum; surface smooth, somewhat dull, often vaguely rugulose basally near suture, often finely, sparsely punctate apically; apices broadly, separately rounded, suture angulate or minutely dentate. Legs short; femora somewhat slender, shining, very sparsely, finely punctate, glabrous except for sparse, recurved setae near lower posterior margins; tibiae less shining, more coarsely, densely punctate than femora, glabrous except for scattered, erect, golden setae and 2 thin lines of dense, golden pubescence covering at least apical halves of lower margins. Abdomen with sternites polished, glabrous and impunctate at middle, sides sparsely punctate, each puncture with a reddish-

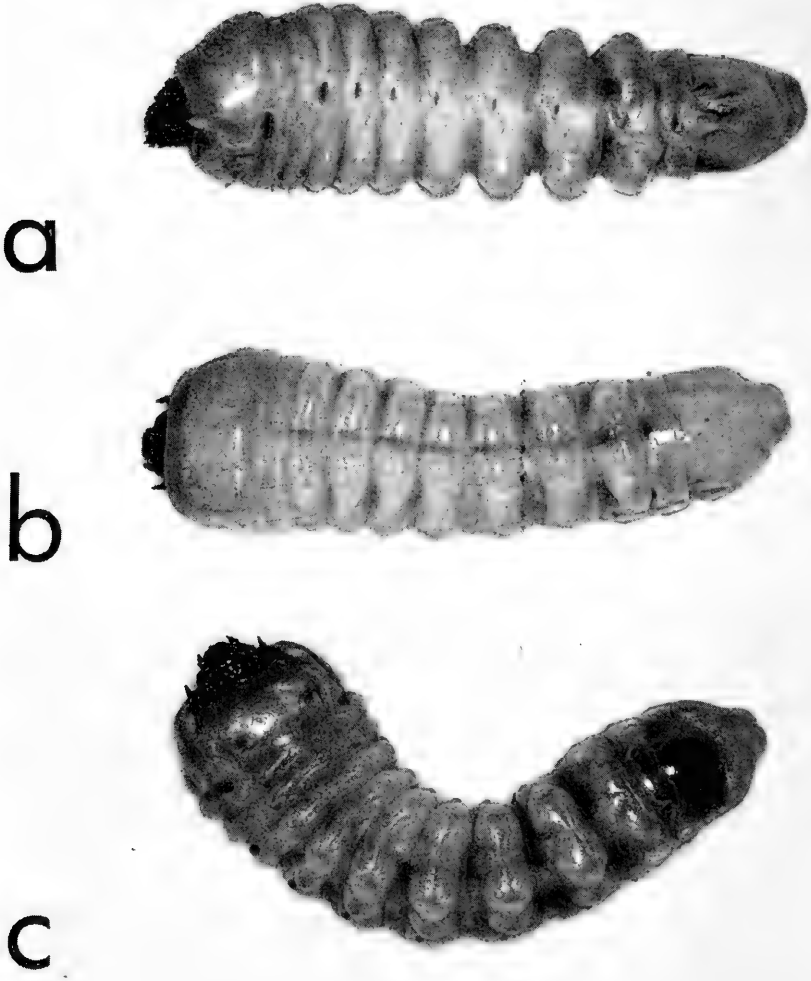

Fig. 5. Presumed mid-instar larva of S. *madericus* found with an adult male in trunk of living *Quercus hypoleucoides*. a, lateral view. b, dorsal view. c, ventral view.

golden recumbent seta, setae becoming denser on lateral and apical margins; 5th sternum transverse, shorter than, or subequal to, 4th, apex broadly emarginate, densely fringed with long, reddish-golden setae. Length, apex of elytron to base of mandible, 26–40 mm.

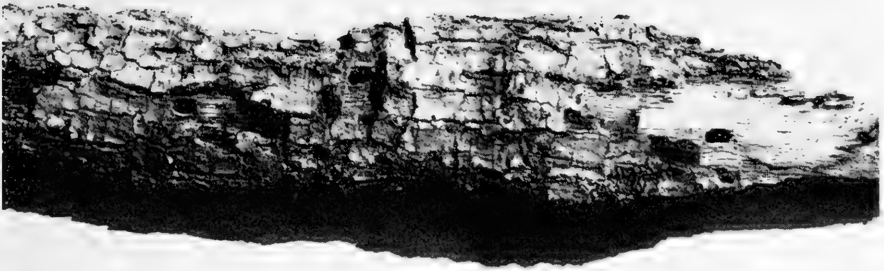

Fig. 6. Fragment of trunk of *Q. hypoleucoides* containing three emergence holes of *S. madericus.*

Female.—Mandible shorter than head, less strongly retracted at base than in male; preapical tooth less prominent; antenna attaining basal ⅓ of elytron, 3rd segment ⅔ as long as scape, 4th through 6th scarcely decreasing, 7th through 10th scarcely increasing in length, 11th subequal to scape, not appendiculate; sides of submentum not or slightly produced over apical recession. Pronotal spines more pronounced, subbasal spine 2–4× as long as remaining spines; prosternum usually more shining and sparsely punctate than in male. Metepisternum less narrow than in male, inner margin only slightly concave. Fifth abdominal sternum longer than 4th, apex truncate, notched, or broadly emarginate. Length, 30–43 mm.

Type-locality.—Roundup Picnic Ground, elevation 5,400 feet, Madera Canyon, Santa Cruz Co., Arizona.

Known range.—Oak woodland of north central Arizona to northwestern Mexico (Fig. 2).

Flight period.—Late June to early August.

Habits.—*Stenodontes madericus* is much less common and widespread than its sympatric congeners *S. logigenis* and *S. dasytomus*, but adults are attracted to light in oak woodland throughout much of southeastern Arizona. The only confirmed host for *S. madericus* is living silver leaf oak (*Quercus hypoleucoides* A. Camus). The latter species is characteristically rather small, the diameter of the trunk seldom exceeding 10 or 12 inches. An adult male (abdomen still distended) and three presumed mid-instar larvae of *S. madericus* were found at the type-locality on 21 June 1977 in the six to eight inch diameter trunk of a living *Q. hypoleucoides* (E. F. Giesbert), near where several adults had been taken at night in July of a previous year, walking on living trunks of the same species (J. S. Cope and D. G. Marqua). (Here it should be noted that the remarks of Hovore and Giesbert (1976), concerning the oak infesting habits of S. *arizonicus*, in fact refer to S. *madericus*.)

The larvae were mining the heartwood and had excavated several intermingling galleries which were parallel to the grain and almost entirely filled with a rather coarse, tightly packed mixture of granular frass and feculae. The extent of the galleries and the simultaneous presence of three larvae and an adult in the same gallery system indicate that the larvae require at least two years to develop and often reinfest the same tree. The larvae construct oval emergence holes, often through scars devoid of bark (Fig. 6), and leave both the holes and the outer two or three inches of the exit galleries open, thus creating the impression the adults have already emerged.

Emergence holes which appear to be those of S. *madericus* are not uncommon in Madera Canyon and other oak woodland regions of southeastern Arizona. Infested trees seldom seem to suffer from the initial attack. However, trees which have been repeatedly infested sometimes appear to be in decline, and on occasion I have seen a large, living oak limb seriously weakened or even broken off as a result of extensive larval work.

Given that most oak infesting cerambycids, including prionines, are not confined to a single host species, it is possible that S. *madericus* attacks several species of evergreen oaks, and perhaps even deciduous oaks. *Quercus hypoleucoides* is certainly not the only host species, since S. *madericus* has been taken in both Oak Creek Canyon and the Superstition Mountains of Arizona where Q. *hypoleucoides* does not occur (Kearney and Peebles, 1960). There are also indications that S. *madericus* does not attack only living trees. Three specimens have been taken from beneath slabs of bark on standing dead oaks—a pair *in copulo* (end-to-end and facing apart) in the Huachuca Mountains of Arizona (F. T. Hovore) and a male in Cave Creek Canyon near Portal, Arizona (A. E. Lewis). In addition, one occasionally finds in southeastern Arizona a standing dead oak thoroughly riddled with emergence holes which appear to be those of S. *madericus*.

Diagnosis.—This species, like *Archodontes melanopus* and the other North American species of *Stenodontes* (but apparently unlike *Neomallodon arizonicus*) is quite variable in size and exhibits significant mandibular allometry, characteristics which undoubtedly have been largely responsible for the confusion of S. *madericus* with other species of Macrotomini, particularly S. *lobigenis*. Despite the fact that S. *madericus* has until now remained unrecognized, most specimens are readily separated from similar forms by the characters given in the preceding keys. The tumid, basally retracted mandibles (Fig. 4) and deeply excavated submentum immediately separate males and major females from other species of *Stenodontes*, and the sculptured submentum and narrow metepisternum readily distinguish all specimens from *Neomallodon* and *Archodontes*. However, minor females of S. *madericus* and S. *lobigenis* are often difficult to separate, primarily because the submental sculpture and mandibular profiles of minor females are not distinctive. Minor females of S. *lobigenis* from the United States, mainland Mexico and northern Baja California are generally separable from specimens of S. *madericus* by their dark brown color and short, denticulate pronotal spines, but specimens of S. *lobigenis* from the cape region of Baja California and from various islands in the Gulf of California are often red brown and have spinose pronotal margins. The latter, however, can be distinguished from S. *madericus* by the inner margin of the mandible, which in S. *madericus* is bidentate and in S. *lobigenis* is vaguely crenate and lacking a distinct subbasal tooth.

Stenodontus madericus clearly belongs to the subgenus *Mallodon* Audinet-Serville, and the description of *Mallodon* given by Linsley (1962) must be modified to accommodate tumid, basally, retracted mandibles. Within the subgenus, S. *madericus* is a member of what Lameere (1902) referred to as the Mexican group of *Nothopleurus* Lacordaire, i.e., S. *lobigenis* and S. *subsulcatus* (Dalman). The essential morphological differences between these species are expressed almost exclusively in the structures of the mandibles and submenta. *Stenodontes subsulcatus* is quite possibly known from only three specimens, all types, none of which I have seen. However, the original description of *Mallodon gnatho* White (1853) and the detailed description of the type of *Nothopleurus ebeninus* Lacordaire by Lameere (1902), who synonymized both with *Prionus subsulcatus* Dalman and placed them in *Stenodontes*, are sufficient to draw the following conclusions. *Stenodontes madericus* is probably most closely related to S. *subsulcatus*, but differs from the latter in the more dramatically recessed submentum, less pronounced mandibular structure and smaller size. The latter, to be sure, is a poor species character but nevertheless, the White type, a male, is 42 mm long and the Lacordaire type, also a male, is 45 mm long. Both are thus larger than the largest male (40 mm) of the rather substantial type-series of S. *madericus*. The mandibles of S. *subsulcatus* are apparently similar to those of S. *madericus*, but differ in having two contiguous preapical teeth on the inner margin and the basal swelling distinctly triangular in profile and terminating apically in a tooth-like process. *Stenodontes subsulcatus* is known only from Honduras and the Yucatan and is therefore considerably separated geographically from S. *madericus*. On the other hand, S. *lobigenis* and S. *madericus* are sympatric throughout most of the range of the latter, and their specific differentiation presumably arose via exploitation of distinct, but contiguous, biomes—evergreen oak woodland and desert scrub.

Remarks.—This species is named to commemorate the type-locality, Madera Canyon, Arizona, long noted for its rich and unusual avifauna and entomofauna by professional scientist and amateur naturalist alike.

Material examined.—Holotype ♂ (U.S. National Museum of Natural History, Washington, D. C., USNM type #75481) from Roundup Picnic Ground, elevation 5,400 feet, VII-14-75, and allotype from Santa Rita Lodge, elevation 4,960 feet, VII-15-75, Madera Canyon, Santa Cruz County, Arizona (D. D. Skiles, at light). Fifty-seven paratypes. Arizona. Coconino County: Indian Gardens, 6 mi N Sedona, 1♀ VIII-7-67 (S. M. Anderson, labelled *Archodontes melanopus serrulatus* ♂). Santa Cruz County, Madera Canyon: 4♀, VI-28–VII-4-73, 2♂, 1♀ VII-15-75 (D. D. Skiles, at light); 1♂, 4♀, VII-18-65, 3♀, VII-19-65, 1♂, 1♀, VII-20-65, 1♂, 2♀, VII-5-75, 4♂, 1♀, VII-20-75 (J. S. Cope, at light and walking on living oak trunks); 1♂, 1♀, VII-11-57(Stange and Harding); 2♀, VI-25-76 (at light), 1♂ (in living oak trunk), VI-21-77 (E. F. Giesbert); 1♀, VII-25-73, 1♂, VII-26-76 (F. T. Hovore, at light); 2♂, VII-10–15-75 (A. E. Lewis, at light); 1♀, VII-29-71 (C. E. Langston, at light); 1♀, VII-11-63, 1♀, VI-28-75 (G. C. Walters, Jr., at light); 1♂, VII-2-65 (D. N. Harrington, 4,880 feet); 1♀, VII-23-65, 1♂, 3♀, VII-8-71, 1♀, VIII-4-72, 1♂, VII-14-75, 1♀, VII-18-75 (D. G. Marqua, at light and walking on living oak trunks). Gila County: Globe, 1♂, July (D. K. Duncan). Cochise County: Carr Canyon Road, elevation 6,000 feet, Huachuca Mts., 1♂, 1♀, (*in copulo* under bark of oak), VII-24-76 (F. T. Hovore); Southwestern Research Station, 5 mi SW Portal, 1♂ (dead about one year), 1♂, 1♀, VII-3-76 (D. D. Skiles, at light); 3 mi SW Portal, 1♂, VII-25-66 (A. E. Lewis, under bark of dead oak). No county given (very old label): Superstition Mts., 1♀, July (D. K. Duncan). Mexico. Chihuahua: 8 mi W Matachic, elevation 7,200 feet, 1♂, VII-8-47 (D. Rockefeller Exp., Schramel, AMNH); 15 mi E Cuauhtemoc, elevation 6,600 feet, 1♀, VII-11-64 (J. A. Chemsak and J. Powell, at light).

Also seen but not included as paratypical owing to the questionable validity of the locality (A. E. Lewis, personal communication), 1♀, labeled Gila Bend, Ariz., 5 Aug 1954, (A. E. Lewis).

Paratypes reside in the collections of the California Academy of Sciences, the American Museum of Natural History, the Essig Museum of Entomology, University of California, Berkeley, and the collections of the author, J. S. Cope, E. F. Giesbert, F. T. Hovore, C. E. Langston, A. E. Lewis, D. G. Marqua, and G. C. Walters, Jr.

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I am indebted to E. G. Linsley and J. N. Belkin for many fruitful discussions and for reviewing the manuscript.

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The major portion of the collection and specimen data were obtained through the generous cooperation of several private collectors: J. S. Cope, E. F. Giesbert, F. T. Hovore, C. E. Langston, A. E. Lewis, D. G. Marqua, and G. C. Walters, Jr. I am particularly grateful to C. E. Langston and F. T. Hovore for information on the rearing of *N. arizonicus* and to E. F. Giesbert for information on the larval habits of *S. madericus* and for comparing specimens of *S. madericus* with material in the Casey collection at the USNM.

I also wish to thank V. Roth and the Southwestern Research Station of the American Museum of Natural History for assistance and collecting privileges, L. D. Skiles for collecting assistance, S. R. Skiles for typing and editing the manuscript, and J. Sells for preparing Fig. 2. The photographic work was done by the author.

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Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California 90024.

Footnote

[1] While *Neomallodon arizonicus* has apparently not been collected in Mexico (see Fig. 2), it is unlikely that this is a result of the species' observance of a political boundary.

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THE IMMATURE STAGES AND BIOLOGY OF *MALLOTA POSTICATA* (FABRICIUS) (DIPTERA: SYRPHIDAE)

Chris T. Maier

Abstract.—The immature stages of *Mallota posticata* (Fabricius), which are described and illustrated, occurred in or near wet treeholes in deciduous trees. Larvae developed in the wet treehole detritus upon which they fed. In central Illinois, larvae of univoltine *M. posticata* attained full size by late summer, 2½–3½ months after hatching, and then they entered diapause. In the spring, they usually crawled out of treeholes and pupariated in the soil at the base of the tree. Laboratory-reared larvae required several months of chilling to terminate diapause and subsequently to pupariate. Males generally pupariated before females, but both remained in the puparium about 13–14 days when they were maintained at 22°C and on a 17 hour photophase and a 7 hour scotophase. Adults exposed to a 0400–2100 photophase eclosed mostly between 0600 and 1000—the equivalent of morning hours in nature.

In the field, adults fed upon open, actinomorphic blossoms which produced substantial quantities of pollen—a requisite for normal ovarian development. Mating, which is described, occurred near flowering plants and near treeholes. Females readily oviposited (17.7 ± 1.30 eggs per clutch) in artificial oviposition containers placed in the forest. Oviposition in containers occurred principally in June between 1100 and 1800 CDT.

The numerous investigations on syrphids in the tribe Eristalini deal mostly with representatives of the genus *Eristalis*, especially *E. tenax* (L.), and only rarely with members of other genera. Eristaline larvae, "rat-tailed maggots," are adapted for an aquatic existence. In particular, they have an extensible, caudal respiratory tube for obtaining atmospheric oxygen, anal papillae for facilitating ionic exchange and an elaborate filtering apparatus for feeding on detritus (Hartley, 1963; Hase, 1926; Krogh, 1943; Krüger, 1926; Roberts, 1970; Wahl, 1900; Wichard and Komnick, 1974). These structures and the external sensory organs have provided most of the characters used in taxonomic descriptions of larvae (Dixon, 1960; Hartley, 1961; Hennig, 1952). Dixon (1960), Doležil (1972), Hartley (1961), Hennig (1952), Johannsen (1935) and others published partial keys to third-instar eristaline larvae.

The larvae of *Mallota bautias* (Walker), *M. cimbiciformis* (Fallen) and *M. posticata* (Fabricius) develop in detritus-containing rot pockets, usually wet treeholes in upright deciduous trees (Becher, 1882; Britten, 1917; Coe, 1953; Johannsen, 1935; Lintner, 1882; Lundbeck, 1916; Snow, 1949). Johannsen (1935), Lintner (1882), Morse (1910) and Snow (1949) described the gross external morphology of one or more of the immature stages of *M. posticata* but largely ignored its life history. The taxonomic descriptions are not sufficiently detailed for use in comparative studies. Furthermore, I shall show that Johannsen's (1935) description of the anal papillae of the larva is erroneous. Unfortunately, Hennig (1952) and Snow (1949) incorporated the spurious information into their taxonomic keys.

Adults of *M. posticata*, apparent Batesian mimics of bumblebees, visit open, actinomorphic blossoms from April to July in the eastern United States (Graenicher, 1910; Robertson, 1928; Waldbauer and Sheldon, 1971; Waldbauer et al., 1977; Maier, unpublished data). Nothing else is published about the behavior of adults except for Curran's (1925) description of the oviposition behavior of an unidentified species of *Mallota*. Fashing (1973, 1974, 1975 and 1976), however, reported that *M. posticata* females are dispersal agents for two species of treehole-inhabiting mites.

Materials and Methods

Descriptions are based on specimens collected in nature and on others reared in the laboratory. Live eggs, larvae and puparia were used for most measurements of external structures. Measurements that were made on immatures or on biological events are usually reported as the mean ± standard error.

The principal research site, Sand Ridge State Forest, is in an extensive sand area in central Illinois near the Illinois River. The vegetation at Sand Ridge consists mostly of oak-hickory forest, disturbed sand prairie, and pine plantations (Maier, 1977a). The forest is dominated by the oaks *Quercus marilandica* Muenchh., and *Q. velutina* Lam. and by the hickories *Carya ovalis* (Wang.) Sarg. and *C. tomentosa* (Poir.) Nutt.

Laboratory colonies were started with the eggs of wild females and maintained for three generations without noticeable deleterious effects. The standard diet for rearing larvae was a 1:1 mixture of Purina Fly Larvae Media (Ralston Purina Co., St. Louis, Missouri) and homogenized treehole detritus. The mixture was saturated with water and usually supplemented with 3–4 grams of Vitamin Diet Fortification Mixture (ICN Pharmaceuticals, Inc., Cleveland, Ohio) per liter of wet diet. Larvae reared in crispers at 22°C and on a 17 hour photophase and a 7 hour scotophase reached full size in approximately three months and then entered diapause. One month later, they were placed in crispers containing moist, coarse treehole detritus and kept at 2°C and on a 10 hour photophase and a 14 hour scotophase. After 4–5 months, the larvae were transferred to 6.5 × 12.5 cm crystallizing dishes which were placed in crispers partially filled with sand. The dishes were filled with the semi-artificial diet and exposed to the initial temperature and photoperiod regimes. In 1–3 weeks, the larvae crawled out of the rearing dishes and pupariated in the sand.

Adults were usually kept in plastic-covered 0.6 × 0.6 × 0.6 meter cages and maintained at 75% relative humidity, at 22°C, and on a 17 hour photophase and a 7 hour scotophase. Each cage contained two Petri dishes of pollen (collected in a pollen trap on a honeybee hive), two dishes with a solution of 10% glucose and 10% sucrose, and a 4 liter plastic jug for oviposition. The jug had a 10 cm circular opening on the side and held 1.5 liters of homogenized, water-soaked treehole detritus and strips of bark. The experiment monitoring ovarian development was carried out in 0.3 × 0.3 × 0.3 meter cages.

The oviposition containers described above were also used to record egg-laying activity in nature. Seasonal and diurnal patterns of oviposition were measured with 20 and 30 containers, respectively.

Descriptions of the Immature Stages

Egg.—Length 1.5 ± 0.01 mm, maximum width 0.6 ± 0.02 mm ($N = 10$). Elongate oval in outline, ends bluntly rounded (Fig. 1). White; chorionic surface microscopically sculptured, pattern under light microscope as in Fig. 1.

Mature third-instar larva.—Body length 20.8 ± 0.72 mm, maximum width 6.4 ± 0.12 mm, length of retracted caudal respiratory tube 13.6 ± 0.58 mm ($N = 14$); ratio of body length to retracted respiratory tube length 1.5:1.0.

Body slightly fusiform, truncate anteriorly, abruptly tapered posteriorly to base of caudal respiratory tube (Fig. 2). Cuticle translucent in life, cream to dirty white after fixation. Segmentation indistinct; longitudinal plicae anteriorly, numerous transverse plicae posteriorly. Short, unpigmented hairs sparsely cover body; longer hairs laterally and posteriorly, in longitudinal bands laterally.

Antenno-maxillary sense organ (AM) and mouth circled by brown spinules (Fig. 3); inflatable, pilose lobes lateral to mouth; verricule between antenno-maxillary sense organ and mouth. Two anterior spiracles (AS), brown, with 17–18 elliptical to circular openings on anteroventrally directed face and its margins (Figs. 2, 4). Ventral prolegs well developed (Figs. 2, 3, 5), 1 thoracic, 6 abdominal pairs. Crochets brown apically,

→

Fig. 1. *Mallota posticata*, egg. Figs. 2–8. *Mallota posticata*, mature third-instar larva. 2, lateral view. 3, ventral view, anterior end. 4, anteroventral view, left anterior spiracle. 5, lateral view, left fourth abdominal proleg. 6, cross section, arrangement of sensilla on abdominal segments 1–7. 7, ventral view, outline of protrusible

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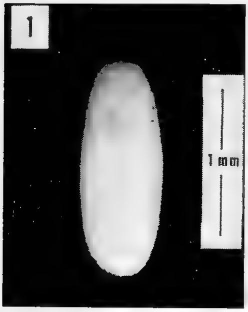

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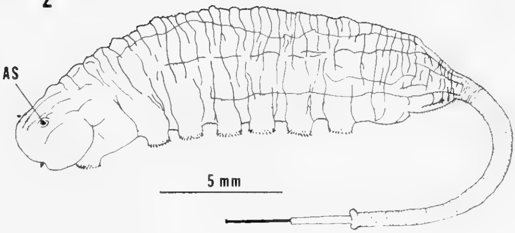

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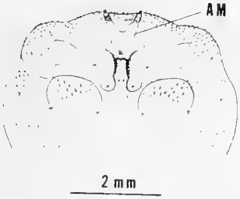

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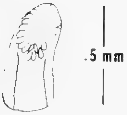

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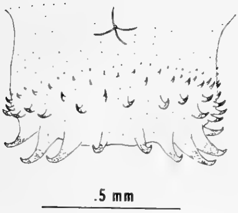

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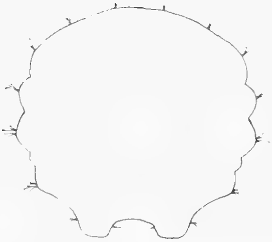

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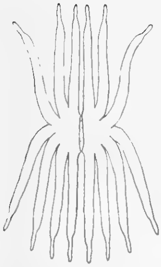

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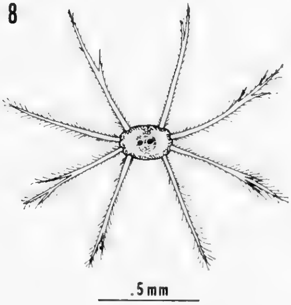

anal papillae. 8, spiracular plate of caudal respiratory tube. Abbreviations: AS, anterior spiracle; AM, antenno-maxillary sense organ.

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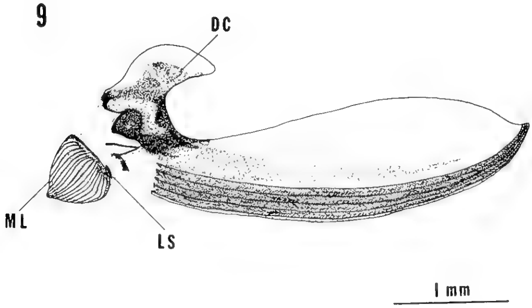

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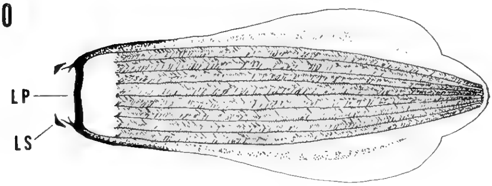

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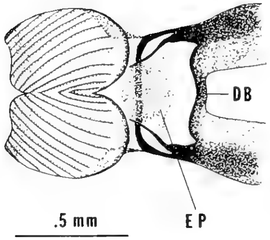

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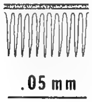

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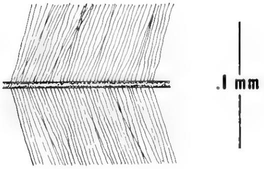

multiserial, in 4–5 rows becoming indistinct dorsally (Fig. 5); crochet arrangement posterolateral at anterior end of body, nearly lateral at posterior end. Abdominal segments 1–7 with 20 sensilla each (Fig. 6); arrangement of sensilla on other segments similar to that described by Hartley (1961) for *Mallota cimbiciformis.* Anal papillae protrusible, 6 anterior ones, 8 posterior ones (Fig. 7). Caudal respiratory tube immediately anterior to brown, sclerotized distal portion, bearing anteriorly directed, unpigmented spines on longitudinal cuticular ridges. Spiracular plate of caudal respiratory tube convex, with 2 prominent spiracular scars centrally, encircled by 8 laterally fringed setae (Fig. 8).

Cephalopharyngeal skeleton as in Figs. 9–13; length 4.1 ± 0.14 mm ($N = 7$). Mandibular lobes (ML) well developed, ribbed (Figs. 9, 11), with comb of filaments on inner ridges (Fig. 12). Pharyngeal sclerite with posteriorly projecting dorsal cornuae (DC) connected by dorsal bridge (DB) (Fig. 11), ribbed cibarial filter ventrally (Figs. 9–10). Pharyngeal sclerite black to amber anteriorly, translucent posteriorly except for light brown, posteriorly tapering strip at each margin of cibarial filter (Figs. 9–10). Two pairs of bars projecting anteriorly from pharyngeal sclerite (Fig. 9), black to amber; dorsal pair unconnected, at lateral margins of brownish epipharyngeal plate (EP) (Fig. 11); ventral pair joined by concave, black to brown, sclerotized bridge (Figs. 10–11); labial sclerite (LS) supported posteriorly by bridge. Floor of pharyngeal sclerite with cibarial filter of 9 filament-lined ridges, converging posteriorly (Fig. 10); inner 7 ridges with single row of filaments on each side (Fig. 13), outer 2 ridges with 1 row of filaments.

Puparium.—Length excluding caudal respiratory tube 14.9 ± 0.25 mm, maximum width 8.1 ± 0.14 mm ($N = 15$).

Inflated, tear-shaped in dorsal view (Fig. 14), fusiform in lateral view (Fig. 15), strongly convex dorsally, nearly flat ventrally. Light brown, entirely rigid. Longitudinal swelling at each dorsolateral margin; indistinct transverse plicae, increasing posteriorly. Sparsely pubescent, larval cuticular ornamentation present but indistinct. Two dehiscent plates at anterior end (Fig. 16); anterior plate trapezoidal, evenly convex, with diverging spiracles at anterior margin. Posterior plate abruptly turned anteroventrally

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Figs. 9–13. *Mallota posticata*, cephalopharyngeal skeleton. 9, lateral view. 10, ventral view, excluding mandibular lobes. 11, anteroventral view, junction between mandibular lobes and pharyngeal sclerite. 12, lateral projections on cuticular ridges of mandibular lobes. 13, filament-lined cuticular ridge of cibarial filter. Abbreviations: DB, dorsal bridge of pharyngeal sclerite; DC, dorsal cornua of same; EP, epipharyngeal plate; LP, labial plate; LS, labial sclerite; ML, mandibular lobe.

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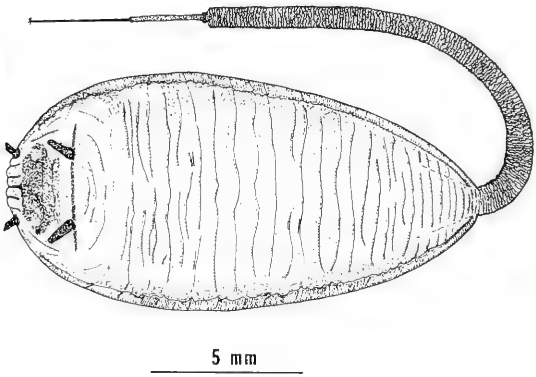

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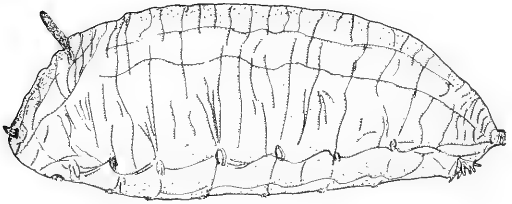

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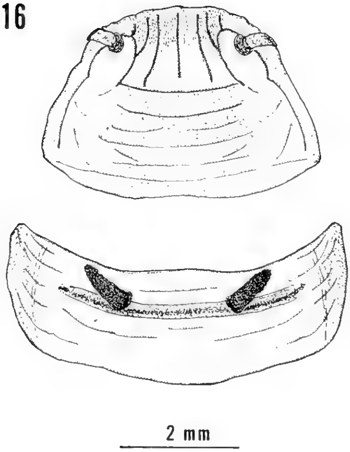

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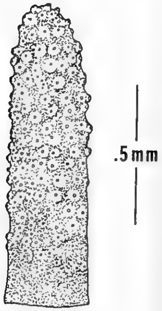

at lateral margins; dorsum nearly rectangular, slightly convex, with nearly straight, diverging, anterodorsally directed pupal respiratory horns. Horns with numerous tubercles except at base and on lower surface (Fig. 17); each tubercle with spiracular opening at apex.

Material studied.—Descriptions based on material from Sand Ridge State Forest, Mason County, Illinois; voucher specimens deposited in the Illinois Natural History Survey.

Johannsen's (1935) brief description of *M. posticata* immatures (preceded by a question mark) agrees with mine except for the number and the arrangement of anal papillae in the larva. He found 13 anal papillae, 6 anterior and 7 posterior, rather than the 14 anal papillae, 6 anterior and 8 posterior, reported here. He did not associate the larva with an adult and, thus, apparently described either another eristaline species, probably a *Mallota*, or a damaged specimen of *M. posticata*. Unfortunately, Lintner's (1882) description is too fragmentary to permit comparison.

The immature stages of the North American *M. posticata* differ from those of the sympatric *M. bautias* (Snow, 1949) and the european *M. cimbiciformis* (Coe, 1953; Hartley, 1961). Although Snow (1949) described only the puparium of *M. bautias*, he noted in a key that the larva has 7 anterior and 7 posterior anal papillae. Furthermore, in contrast to the *M. posticata* puparium, the *M. bautias* puparium described by Snow (1949), and others examined by me, have a nearly flat anterior dehiscent plate, the distal portion of the pupal respiratory horns bent dorsally, and distinct transverse plicae on the abdominal dorsum.

The *M. cimbiciformis* larva has no pubescence on the posterior abdominal dorsum, 25 openings on each anterior spiracle, and 12 anal papillae (Hartley, 1961). Any one of these characteristics separates *M. cimbiciformis* from *M. posticata*. In addition, the absence of dorsal abdominal pubescence and the greater number of spiracular openings on the anterior spiracle of the *M. cimbiciformis* puparium distinguishes it from the *M. posticata* puparium.

The general morphology of the cephalopharyngeal skeleton of *M. posticata* resembles that of several *Eristalis* species (Hartley, 1963; Wahl, 1900) and *Myiatropa florea* (L.) (Roberts, 1970), taxonomically related species with similar feeding habits. Therefore, Roberts' (1970) account of the function of the feeding structures in *M. florea* probably applies well to *M. posticata* and most other eristaline larvae.

←

Figs. 14–17. *Mallota posticata*, puparium. 14, dorsal view. 15, lateral view, excluding caudal respiratory tube. 16, dehiscent plates. 17, posterodorsal view, left pupal respiratory horn.

Biology

Larvae were collected from treeholes in upright, living *Carya* spp., *Liquidambar styraciflua* L., *Populus deltoides* Marsh, *Quercus alba* L., *Q. marilandica*, *Q. velutina* Lam., and *Ulmus* sp. in Illinois, Indiana or Michigan. The openings to these treeholes occurred at various heights but were mostly near ground level. The cavities usually contained more than 3 liters of detritus and held standing water for more than 2 months out of the year. There were 1–51 larvae per treehole; the number generally increased with the quantity of detritus. The 51 larvae were in a treehole in *Populus deltoides* that contained approximately 60 liters of detritus. In the summer, larvae were usually near the bottom of treeholes where the particles of detritus were the smallest and the moisture was the greatest. Other organisms commonly found in the same treeholes included Acarina (Fashing, 1973, 1974, 1975 and 1976), helodids (*Elodes*, *Prionocyphon*), ceratopogonids, psychodids *(Telmatoscopus)* and rarely other syrphids (e.g., *Somula decora* Macquart and *Spilomyia longicornis* Loew). *Mallota bautias* larvae never occurred in treeholes containing *M. posticata* larvae.

The filter-feeding larvae of *M. posticata* consumed fine-grained detritus and other material trapped in treeholes. Most treehole detritus originates from trees, for example, from leaves, wood and acorns. Wind and the activities of ants facilitate the deposition of detritus in treeholes. In the laboratory, larvae often protruded and then pulsated their anal papillae while feeding. Thus, in addition to an osmoregulatory function (Krogh, 1943; Wichard and Komnick, 1974), the anal papillae may also be used to put food particles into suspension and to circulate them.

In nature, larvae attained full size and weight (0.35–0.55 grams) and entered diapause by late summer, approximately 2½–3½ months after hatching. Diapausing larvae were inactive, relatively inflexible and pink (due to particles of unknown origin suspended in the hemolymph). These larvae also had an empty gut and contracted cephalothoracic region.

Larvae overwintered in diapause in treeholes. In early spring, they commonly congregated against the inner treehole wall in moist but not water-soaked detritus. Exposure to cold was necessary for the termination of diapause and for the synchronous emergence of adults, an important consideration in any univoltine species. In the laboratory, full grown larvae that were subjected to 2°C and a 10 hour photophase and 14 hour scotophase for 4–5 months and then to 22°C and a 17 hour photophase and 7 hour scotophase pupariated over a 1–3 week period. By contrast, larvae that were continuously maintained at 22°C and on a 17 hour photophase and a 7 hour scotophase failed to pupariate within 14 months after hatching.

At Sand Ridge State Forest, larvae usually left treeholes from April to June and pupariated in the surface of the sandy soil within 1–2 m of

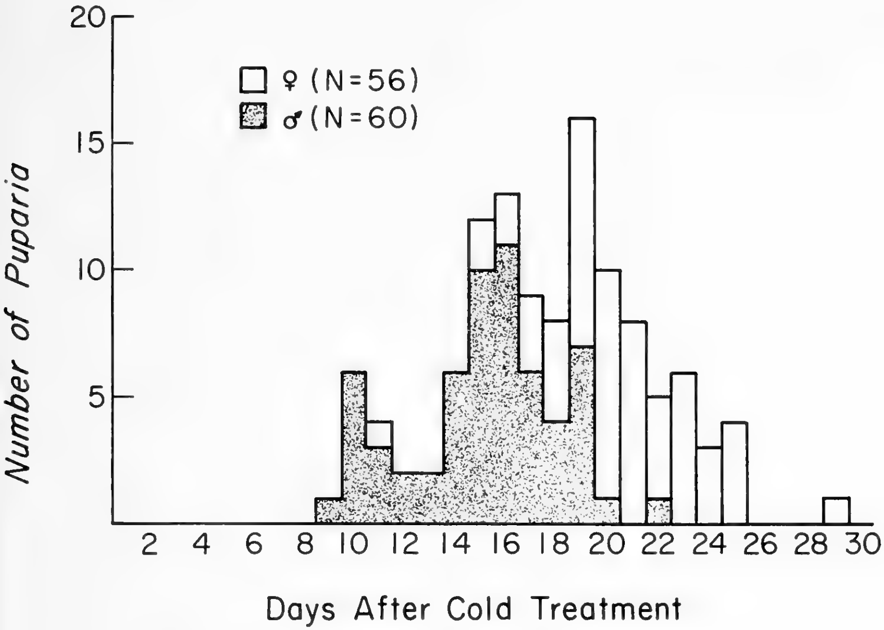

Fig. 18. Pattern of *Mallota posticata* pupariation after exposure to 2°C and a 10 hour photophase and a 14 hour scotophase.

the tree trunk. They occasionally remained in the treeholes and pupariated near the surface of the detritus in the cavity. Pupariation usually occurred over a 2 week period at any one treehole. Although puparia were frequently discovered, the actual departure of larvae from treeholes was witnessed only twice, at 1400 and 1515 CDT on 19 May 1975. Ants foraging in the vicinity attacked both larvae. One escaped and pupariated in the soil, and the other climbed the tree until out of sight. At 1100 on the following day, ants successfully captured and killed a larva at the same treehole.

In the laboratory, most larvae crawled out of rearing dishes between 1100 and 1900 of a 0400–2100 photophase, wandered on the sand up to several hours and finally pupariated in the sand, often under the dishes. The pupal respiratory horns protruded through the puparium 54–72 hours later. Larvae that were exposed to 2°C and a 10 hour photophase for 140 days began to pupariate only 9 days after they were switched to 22°C and a 17 hour photophase (Fig. 18). The main time from the termination of the cold treatment to pupariation was 15.2 ± 0.38 days for males and 20.4 ± 0.41 days for females. Males and females remained in the puparium 12–15 days and 13–15 days, respectively (Table 1). Most males (48.72%) eclosed on day 13, and most females (60.00%) eclosed on day 14. Similarly,

Table 1. Time spent in the puparium by both sexes of *Mallota posticata* at 22°C and on a 17 hour photophase and a 7 hour scotophase.

Days in puparium[1]	Males		Females	
	Number	% of total	Number	% of total
12	2	5.13	0	0.00
13	19	48.72	8	22.86
14	16	41.02	21	60.00
15	2	5.13	6	17.14
Total	39		35	

[1] Puparia were collected and observed at 1500 each day.

Lintner (1882) reported that a male and a female, respectively, spent 12 and 14 days in the puparium.

Eclosion was concentrated between 0600 and 1000, with a distinct peak at 0700, when the photophase extended from 0400–2100 (Fig. 19). In nature, individual adults were seen to eclose at approximately 0800, 1000, and 1100 CDT. Akre et al. (1973) also noted a morning peak in eclosion for the syrphid *Microdon cothurnatus* Bigot.

Adults frequented open, actinomorphic blossoms of species which produce substantial quantities of pollen per flower or inflorescence. In central Illinois, they fed on the pollen, nectar, or both of *Ceanothus americanus* L., *Celastrus scandens* L., *Cornus drummondi* Meyer, *C. racemosa* Lam., *Heracleum lanatum* Michx., *Osmorhiza* sp., *Pastinaca sativa* L., *Prunus serotina* Ehrh., *Ptelea trifoliata* L., *Rhus glabra* L., *Rosa carolina* L., *Rubus allegheniensis* Porter, *R. occidentalis* L., *Sambucus canadensis* L., and *Viburnum* sp. In other parts of their range, they visited *Maianthemum canadense* Desf. (Graenicher, 1910) and *Rosa setigera* Michx. (Robertson, 1928). At Sand Ridge State Forest, adults foraged primarily on *Cornus drummondi*, *C. racemosa*, *Rosa carolina* and *Sambucus canadensis* and demonstrated considerable flower constancy (Maier, 1977b).

Table 2 shows that virgin females required pollen, a protein source, for normal ovarian development. In the absence of pollen, little growth was evident after 8 days; but with pollen some eggs were fully formed after 2–4 days. Schneider (1948) also found that pollen consumption was a prerequisite for rapid ovarian development in the syrphid *Episyrphus balteatus* (De Geer).

Maier (1977b) noted that the mate-seeking activities of *Mallota posticata* males were coordinated temporally and spatially with female activity. In the morning, males searched blossoms to find feeding females. In the afternoon, most males defended territories around wet treeholes and attempted to mate females arriving to oviposit. Matings occurred at both sites.

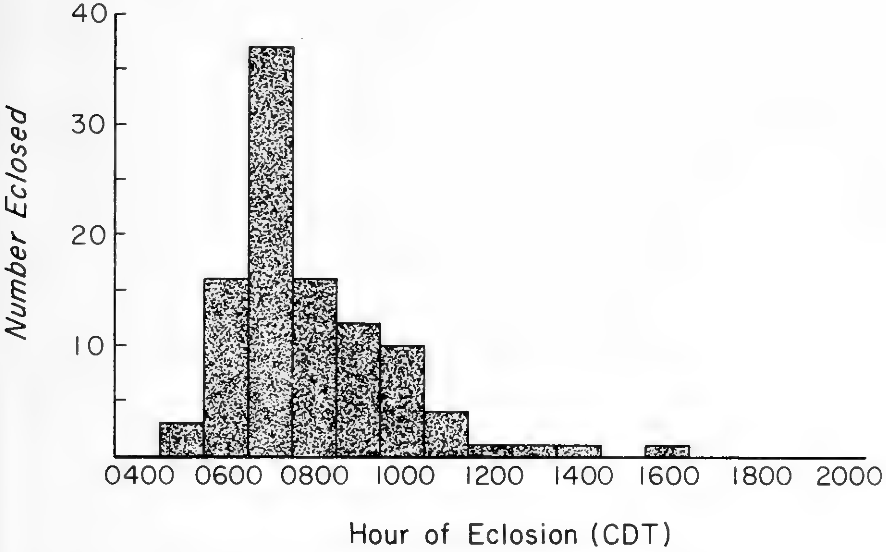

Fig. 19. Periodicity in the eclosion of *Mallota posticata* adults at 22°C and on a 17 hour photophase (0400–2100 CDT).

No overt courtship was evident prior to copulation in *M. posticata.* Males responded almost instantaneously to flying or stationary females. In less than 2 seconds, a male grasped a female and achieved genital contact. Often a brief flight followed with the male carrying the female. Pairs alighted within 1–10 m of the site of encounter, generally on foliage, the trunk of a tree or occasionally on the forest floor. The male usually hooked his prothoracic and mesothoracic tarsal claws onto the costal wing margins of the female. He clasped the abdomen of the female with his metathoracic tibiae and enlarged femora. A shrill sound, apparently created by the vibrating thoracic sclerites of one or both flies (Aubin, 1914), fre-

Table 2. The average weights (mg) of the ovaries of unmated *Mallota posticata* females that were fed pollen or pollen-free diets for 2, 4, 6 or 8 days after eclosion.

Days after eclosion	Number	Without pollen	Number	With pollen
2	4	3.5 ± 0.28	5	21.0 ± 3.28
4	3	3.5 ± 0.19	4	26.5 ± 4.38
6	3	3.7 ± 0.26	4	32.6 ± 1.47
8	3	3.8 ± 0.06	5	46.7 ± 5.66

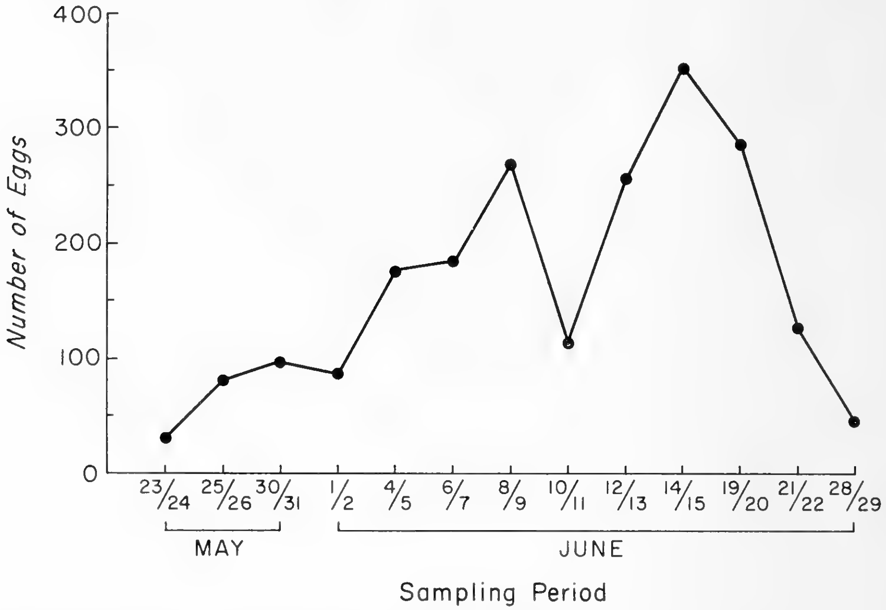

Fig. 20. Number of *Mallota posticata* eggs laid in 20 artificial oviposition sites during 2-day periods between 23 May and 29 June 1976.

quently accompanied the initiation of mating. If a female was not initially receptive, the male moved anteriorly, maintained a firm grip on the female and vigorously stroked the eyes of the female with his prothoracic legs. A male repeatedly stroked an unreceptive female at brief intervals until one or both departed.

In the laboratory, both sexes mated frequently during the first 20 days of their life. One male captured at a flower, marked and released was resighted 11 days later while mating near a treehole. Most pairs copulated for 1–3 hours in cages, but the duration of actual sperm transfer is unknown.

Gravid females flew upwind to treeholes. They circled all trees within 10 m of a tree containing a treehole and, after locating the treehole, usually hovered at the entrance for 0.5–1.0 minute before landing. Hovering often included intermittent 0.5–1.0 second bobbing or down-and-up flights before the opening of a treehole. After landing, females meticulously probed crevices in the bark near the opening or in the wood of the inner wall of the treehole with their ovipositor. Once they selected an oviposition site, they rapidly laid a group of eggs. Eggs were deposited in one or rarely two areas of a treehole, typically under bark at the entrance, above the water line on the inner treehole wall or on the water surface. The mean egg clutch, which was laid in detritus-containing artificial oviposition sites

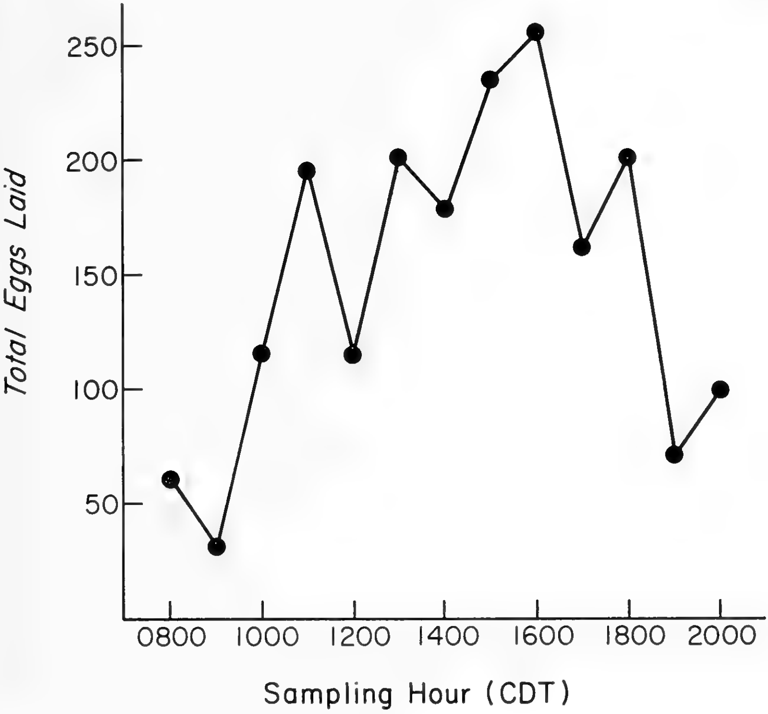

Fig. 21. Total number of *Mallota posticata* eggs laid per hour in 30 artificial oviposition sites uniformly distributed over 0.5 hectare of forest floor and monitored for 10 days in June 1976.

placed in the forest understory, was 17.7 ± 1.30 eggs ($N = 103$). The mean time from hovering to departure at a natural treehole was 20.3 ± 3.63 minutes ($N = 6$). Thirty females placed in the same laboratory cage laid 11,474 eggs over 30 days, an average of 382.4 eggs each.

In 1976 at Sand Ridge State Forest, egg-laying in artificial oviposition sites was concentrated in June, with a peak on 14–15 June (Fig. 20). Little oviposition occurred prior to mid-May or after early July. The oviposition peak on 14–15 June probably reflects a peak in female emergence in early June. In the laboratory, females commenced ovipositing 3–6 days after eclosion and deposited most of their eggs in the first 15–20 days of their life. In nature, females oviposited primarily between 1100 and 1800 CDT in artificial oviposition sites (Fig. 21). The relatively low egg-laying activity between 0800 and 1000 corresponds to the period when females are feeding at flowers growing in fields adjacent to forests (Maier, 1977b).

In laboratory cages, the mean longevity of adults was 19.2 ± 2.23 days ($N = 23$) for males and 21.4 ± 2.33 days ($N = 25$) for females. Two males of unknown age, which were captured at flowers and marked, were resighted 11 and 15 days later.

In conclusion, several of the significant developmental events in the life of *M. posticata* have apparently been selected to occur in the spring when environmental conditions are most favorable. After the termination of diapause, larvae pupariate and adults subsequently eclose as numerous species of flowers began to blossom near suitable larval habitats in deciduous forests. Most spring flowers have an unspecialized floral morphology which permits the adult syrphids to feed easily on the pollen, a requisite for rapid ovarian development, and on the nectar, an energy source. Furthermore, fragile, young larvae probably have a better opportunity for survival in the spring than they do later because the water level in treeholes is highest and the quantity of detritus is greatest due to the accumulation during the previous two seasons.

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Department of Entomology, University of Illinois, Urbana, Illinois 61801.

Present address.—Department of Entomology, Connecticut Agricultural Experiment Station, P. O. Box 1106, New Haven, Connecticut 06504.

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OVIPOSITION AND HOST FEEDING BEHAVIOR OF *APHELINUS ASYCHIS* (HYMENOPTERA: CHALCIDOIDEA: APHELINIDAE) ON *SCHIZAPHIS GRAMINUM* (HOMOPTERA: APHIDIDAE) AND SOME REACTIONS OF APHIDS TO THIS PARASITE

Hillary Boyle and Edward M. Barrows

Abstract.—Fifty-four *Aphelinus asychis* (Walker) were observed during their first encounters and ovipositional attacks with unparasitized *Schizaphis graminum* (Rondani). Oviposition occurred when wasps inserted their ovipositors in aphids for at least 60 s, and aphids were not paralyzed prior to or during ovipositor insertion. Before leaving aphids, 65% of the wasps made single ovipositor eversions (SE's), 35% made multiple ovipositor eversions (ME's). Everted ovipositors did not always pierce aphids. Single eversions (as opposed to ME's) preceded oviposition in 75.7% of 33 observations. Durations of ovipositor eversions which preceded oviposition were significantly longer than durations of eversions that did not precede oviposition. Twenty wasps were observed host feeding. Prior to feeding, wasps stung and paralyzed aphids. Oviposition and host feeding were discrete activities always carried out on separate aphids. Wasps' initial approaches and attacks on aphids, however, were similar in both types of attack. Wasps took significantly longer to sting aphids than to oviposit. Aphid reactions to wasps included body jerking, antennating, walking away and kicking with one leg. Aphids reacted violently to stinging and some ovipositional attacks. Alarm behavior in some aphid groups occurred.

This study was conducted in an attempt to identify behaviors involved in oviposition and host feeding of a hymenopterous parasite, *Aphelinus asychis* (Walker), on the greenbug, *Schizaphis graminum* (Rondani). In addition, some reactions of aphids to wasp presence and attacks were noted.

Aphelinus asychis was first introduced into the United States in 1968 to help control *Schizaphis graminum* which was first found in the United States in 1882 and presently causes millions of dollars damage annually to grain crops, e.g., *Sorghum vulgare* (Pers.).

Although *Aphelinus asychis* is a potentially valuable biocontrol agent against *Schizaphis graminum*, there has never been a detailed study of its oviposition and host feeding behavior. The only descriptions of host feeding (Esmaili and Wilde, 1972; Cate et al., 1973) are brief, lack detail as to the frequency of various behaviors and are inconsistent as to the duration of ovipositor insertion. Oviposition by *A. asychis* has been observed (Rogers, 1976) but never described in detail.

Materials and Methods

Sorghum vulgare was grown in 355 cm^3 plastic pots in a greenhouse. When about 10 cm tall, plants were transferred to a separate area and infested with *Schizaphis graminum*.

Pots with about 4 plants and 10 aphids per plant were transferred to the laboratory and placed in 42,000 cm^3 terraria. Each terrarium held 26–32 pots. Terraria were fitted with clear plexiglass tops, each with 2 ventilation holes covered with nylon mesh and 1 access hole with a 60 cm long nylon mesh sleeve which was tied closed when not in use. Several *Aphelinus asychis* were placed in some terraria and allowed to feed on and parasitize aphids. All terraria were kept under plant-growth fluorescent bulbs for 12 h per day. Laboratory temperature was from 20.0–26.5°C.

Gelatin capsules (no. 1) were used to capture and carry individual adult wasps and to isolate and hold individual mummies. This reduced or eliminated possible injury to wasps which frequently occurs when using a camel's hair brush.

A total of 54 wasps was observed for 1 h each at about 24°C. To observe oviposition and host feeding of *A. asychis* on *S. graminum*, a blade of *Sorghum*, with a minimum of three feeding aphids, was placed in a plastic petri dish; one *A. asychis* female was also placed in the dish which was then covered. Observations were made through a dissecting microscope. All aphids used for observations were taken from unparasitized cultures. This method is similar to that of Goff and Nault (1974).

Behavior that was observed included oviposition host feeding and reactions of aphids to the presence of and attacks by wasps. Attacks were timed with a stopwatch from the moment the wasp turned and everted her ovipositor to the moment she retracted it.

In addition, 16 aphids were dissected to determine whether oviposition actually took place when a wasp's ovipositor pierced the aphid. Five aphids were dissected after having been fed on to determine whether oviposition occurred.

In reporting results, the symbol $\bar{x}$ is used to denote a mean; *M*, median; *TEP* test for the equality of two percentages (Sokal and Rohlf, 1969); *MWUT*, Mann-Whitney *U*-test; and *WMPT*, Wilcoxon's matched pair test. All numerical data are based on randomly-selected animals and observations.

Results and Discussion

Ovipositional attacks.—In "typical" ovipositional attacks, *Aphelinus asychis* walked on substrates and tapped surfaces with extended antennae.

On encountering *Schizaphis graminum* by touching or coming within about 1 cm of them, wasps either retreated or stopped and withdrew antennae, leaving only flagellae slightly extended and quivering. If aphids were not within ovipositor reach, wasps slowly approached and antennated them with only flagellae extended.

When they were sufficiently close to aphids, wasps began to "sway," rocking their bodies from side to side. Occasionally, swaying was interrupted several times for a few seconds each time while wasps lowered antennae and remained motionless. Swaying was occasionally accompanied by wasps' grooming their metasomas with hind legs, grooming hind legs with middle legs or both. Wasps also either turned their heads slightly from side to side or kept them still.

After approaching and facing aphids, wasps rapidly turned about 180° to the left or right, everted ovipositors and stabbed at aphids. If ovipositors did not make immediate contact with aphids, wasps usually made one or more stabbing attempts.

When ovipositors pierced aphids, wasps stood motionless and kept antennae lowered for the duration of ovipositor insertion (Fig. 1). Occasionally, wasps made slight thrusts with ovipositors.

Oviposition occurred when everted ovipositors pierced and were inserted in aphids for at least 60 s; this was determined by dissecting 16 aphids immediately after ovipositional attacks in which everted ovipositors were in aphids from 4–542 s. Immediately before retracting ovipositors, wasps raised heads and extended antennae slightly. After wasps oviposited and retracted ovipositors, they retreated.

Although there are no other published descriptions of oviposition for *Aphelinus asychis*, several aspects of this behavior are similar to those reported for other parasitic hymenopterans. Observations suggest that *A. asychis* usually touches or is within 1 cm of aphids before attacks are initiated. Messenger (1967), reported that *Praon exsoletum* (Nees) detected hosts only after actually contacting them with antennae, and he concluded that the wasp's distance perception was limited. Similar observations have been made with *Lysephlebus testaceipes* (Cresson) (Webster and Phillips, 1912), *Tetrastichus flavigaster* Brothers and Moran (Moran et al., 1969) and *Aphelinus flavus* Thompson (Hamilton, 1973). As in most *A. asychis* observed in this study, females of each of the above species appeared to encounter hosts during apparently "nondirected" wanderings and react to hosts after contact.

Wasps probably gain sensory information as to host suitability and appropriateness of ovipositor insertion sites when they antennate aphids and sway prior to ovipositor eversion. Webster and Phillips (1912) observed *A. nigritus* Howard approach, antennate, and sway in front of *Schizaphis graminum* in a manner similar to that of *Aphelinus asychis*. Antennation of hosts prior to ovipositor eversion has also been reported for

Fig. 1. Everted ovipositor of *Aphelinus asychis* female piercing *Schizaphis graminum.*

A. mytilaspidis (Marchal, 1909), *Praon aguti* Smith, *Lysephlebus testaceipes* (Sekhar, 1957), *Tetrastichus flavigaster* (Moran et al., 1969), and *Aphelinus flavus* (Hamilton, 1973). Moran et al., (1969) presumed that antennation functions in olfactory identification of the host by the wasp. Chalcidoid antennae have sense organs necessary for host finding, according to Askew (1971). After their ovipositors are inserted into hosts, sense organs located on ovipositors probably supply additional information to wasps concerning host suitability (Moran et al., 1969; Askew, 1971).

The following results, except where otherwise indicated, are based on the first observed ovipositor eversions, either single or multiple, which each of 54 wasps made with a different, unparasitized aphid.

When attacking aphids, wasps exhibited either single ovipositor eversions (SE's) or multiple ovipositor eversions (ME's); ME's were comprised of from 2–14 eversions. Everted ovipositors did not always pierce or even contact aphids, and piercing was not always followed by oviposition. In SE's which they made after approaching aphids, wasps turned about 180° away from aphids, everted and retracted ovipositors once, and retreated. In ME's, wasps turned 180° away from aphids, everted and retracted ovipositors, turned 180° to face aphids, turned 180° again, everted and retracted ovipositors a second time; this sequence of 3 turns was repeated from 3–14 times before wasps retreated. Figure 2 shows sequences of behaviors displayed during first encounters of 54 *A. asychis* with 54 *Schizaphis graminum* during 1 h observation periods.

Single ovipositor eversions, as opposed to ME's, occurred 64.8% of the time, and SE's preceded oviposition in 75.7% of 33 observations. This suggests that *Aphelinus asychis* budgeted time and energy efficiently in that they usually pierced *Schizaphis graminum* only once before ovipositing. Wasps that pierced aphids several times before ovipositing may have been attempting to gain additional information as to whether or not aphids were already parasitized, to place their ovipositors in more favorable sites within aphids, or both. Wasps that pierced aphids but failed to oviposit may have received stimuli indicating that aphids were unsuitable for parasitization. If this is the case, evaluation and rejection of unsuitable hosts could be accomplished in a relatively brief time of 2 to about 59 s.

Of the total time spent in everting ovipositors, 35 wasps spent 94.0% of this time in SE's preceding oviposition; 19 wasps spent 51.6% of this time in ME's preceding oviposition. There is a significant difference between these groups ($p = 0.0003$, *TEP*). In SE's, wasps pierced, presumably evaluated the suitability of aphids and oviposited in significantly less total time than in ME's.

Praon exsoletum exhibits similar behavior. In studying its daily ovipositional pattern, Messenger (1967) found that *P. exsoletum* oviposited from 18–24 times in 20–30 min, making one ovipositor insertion per aphid. After a period of rapid ovipositing, however, wasps repeatedly struck at aphids before ovipositing. As in *Aphelinus asychis*, these ME's consumed more time and preceded fewer ovipositions than SE's. A study to determine the daily ovipositional pattern of *A. asychis* could be helpful.

Durations of SE's which preceded oviposition were not significantly different from durations of the last eversion of ME's which preceded oviposition ($U = 94$, $p > 0.05$, $N_1 = 20$, $N_2 = 8$, *MWUT*). Nor were SE's which did not precede oviposition significantly different from durations of ME's which did not precede oviposition ($U = 58$, $p > 0.05$, $N_1 = 10$, $N_2 = 11$, *MWUT*).

Durations of SE's which preceded oviposition were significantly longer than durations of SE's which did not precede oviposition ($U = 198$, $p < 0.002$, $N_1 = 20$, $N_2 = 10$, *MWUT*). Durations of ME's which preceded oviposition were also significantly longer than durations of ME's which did not precede oviposition ($U = 88$, $p < 0.001$, $N_1 = 11$, $N_2 = 8$, *MWUT*).

Wasps made initial approaches to aphids from the front, rear or either side. In ME's, wasps made each ovipositor eversion from the same position relative to the aphid. Rear approaches seemed to precede oviposition more

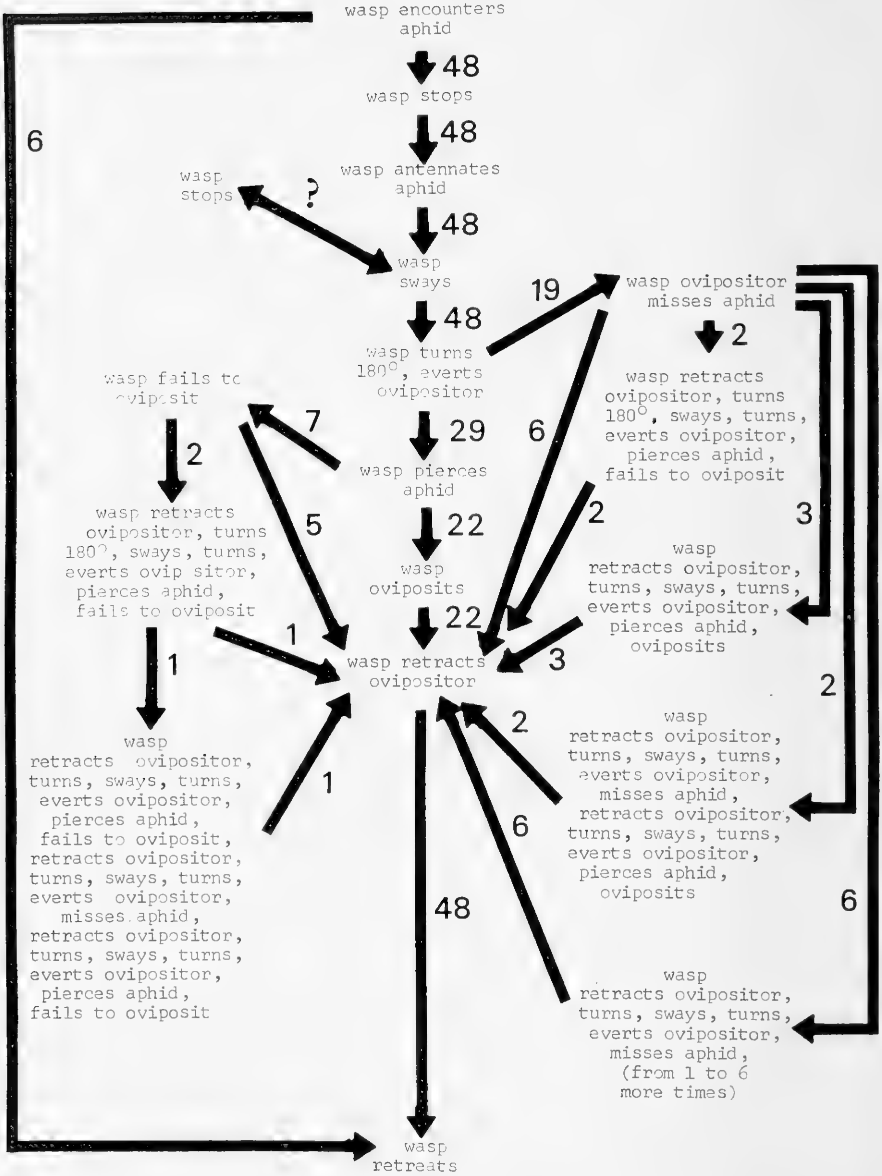

Fig. 2. Behaviors exhibited during first encounters of 54 different *Aphelinus asychis* with 54 different *Schizaphis graminum*. Numbers by arrows indicate frequencies of changes from one behavior (or sequence of behaviors) to another. Question mark indicates that frequency was not noted. See text for further explanation.

often than front or lateral approaches, but sample sizes were too small to allow statistical analysis.

Twenty-six wasps were observed for the direction of turn immediately prior to everting ovipositors in SE's and ME's. In ME's, as noted above, wasps turned about 180° to face aphids after retracting ovipositors, and then they turned again immediately prior to everting ovipositors. They did this two or more times. Turns made immediately prior to ovipositor eversion were in the alternate direction (e.g., right, left or left, right) to the previous turn prior to ovipositor eversion in 53.8% of the cases; 46.1% of such turns were in the same direction (e.g., right, right or left, left) as the previous turn observed. There was no significant difference in turning direction compared to a hypothetical turning of either right or left 50.0% of the time ($0.9 > p > 0.5$, TEP).

Stinging and host feeding.—Host feeding is common among chalcidoids and represents an example of economy in time and effort, in that individual hosts provide food for both adults and progeny (Askew, 1971). Esmaili and Wilde (1972) and Cate et al. (1973) found that host feeding by newly emerged *A. asychis* almost always preceded oviposition.

Nutrients obtained from host feeding by *Aphelinus* and other genera are probably necessary for oogenesis (DeBach, 1943; Moran et al., 1969; Askew, 1971). Oogenesis occurs throughout the adult life of *A. semiflavus* (Howard) (Schlinger and Hall, 1959) as it probably does in *A. asychis*. Therefore, periodic host feeding is probably necessary to obtain nutrients for continuous oogenesis.

Twenty *A. asychis* were observed feeding on 20 different, unparasitized *Schizaphis graminum*. Wasps stung and paralyzed aphids, then they fed from wounds made by ovipositors.

Stinging attacks were initially indistinguishable from ovipositional attacks. Wasps approached and antennated aphids, swayed, turned, everted ovipositors and pierced aphids in apparently the same manner as in ovipositional attacks. Wasps presumably injected, through their ovipositors, a paralyzing agent into aphids.

The first noticeable difference in wasp behavior during stinging attacks, as compared to ovipositional attacks, occurred after aphids were effectively paralyzed and their movements merely uncoordinated leg waving. Wasps (with their ovipositors still inserted in aphids) usually backed up slightly and stood with their hind legs on aphids. Wasps remained in this position, motionless, except for occasional thrusts of ovipositors and with antennae lowered, for several more minutes.

As in ovipositional attacks, immediately prior to retracting ovipositors, wasps raised their heads and slightly extended their antennae. Wasps then immediately made another stinging attack on the same aphids or antennated aphids to locate wounds made by ovipositors. If they did not locate wounds, wasps made additional stinging attacks, usually of shorter duration than the first ones.

When wasps found wounds, they antennated them for several seconds, then positioned their heads over wounds, lowered their bodies and fed. Feeding continued for several minutes and usually took longer than stinging. Wasps either fed once and retreated or alternately stung and fed from the same aphid before retreating.

Figure 3 shows the behavioral sequence of stinging attacks and feeding by 20 *Aphelinus asychis* on 20 *Schizaphis graminum.* This sequence begins with wasp ovipositor insertion into aphids; behavioral sequences occurring before this are similar to those for ovipositional attacks.

Initial approach to and attack of hosts is similar for both oviposition and stinging in *Aphelinus asychis, A. flavus* (Hamilton, 1973), *A. semiflavus* (Schlinger and Hall, 1959), *A. mytilaspidis* (Marchal, 1909) and *Tetrastichus flavigaster* (Moran et al., 1969). In our study, after initiation of stinging attacks by *Aphelinus asychis,* the first noticeable difference in behavior compared to ovipositional attacks was their placing hind legs on aphids. This has also been observed by Esmaili and Wilde (1972). The function of this behavior has not been studied, but it might allow wasps to thrust ovipositors deeper into aphids.

Paralyzing aphids by *A. asychis* prior to their feeding probably facilitates this activity. Unparalyzed aphids would not be likely to remain still while wasps fed at their wounds.

Wasps were never observed paralyzing aphids in which they had oviposited, nor has this been reported in the literature for *A. asychis.* Parasitized aphids remain alive and mobile for several days before mummification and thus provide one means for wasp dispersal.

Of the 20 wasps observed host feeding, 11 approached aphids from the front, 7 approached from the rear and 2 approached from the sides of aphids. All subsequent stinging attacks and feeding were made from the approach position. In their first stinging attacks on aphids, 10 wasps turned to the right and 10 turned to the left prior to ovipositor eversion.

In attacks by 18 wasps, durations from the beginning of the initial paralyzing sting to when wasps placed hind legs on aphids were from 210–570 s ($\bar{x} = 330$, $M = 390$). Esmaili and Wilde (1972) reported durations of from 120–180 s for this activity. Wasp hind leg placement on aphids always occurred after their paralysis.

Durations of initial paralyzing stings, before wasps either began feeding or attempted to find sites of ovipositor insertion, were from 277–1,399 s ($\bar{x} = 598$, $M = 838$, $N = 20$). These durations were significantly longer than durations of SE's which preceded oviposition ($U = 395$, $n_1 = 20$, $n_2 = 20$, $p < 0.001$, $MWUT$). Thus, wasps took significantly longer to para-

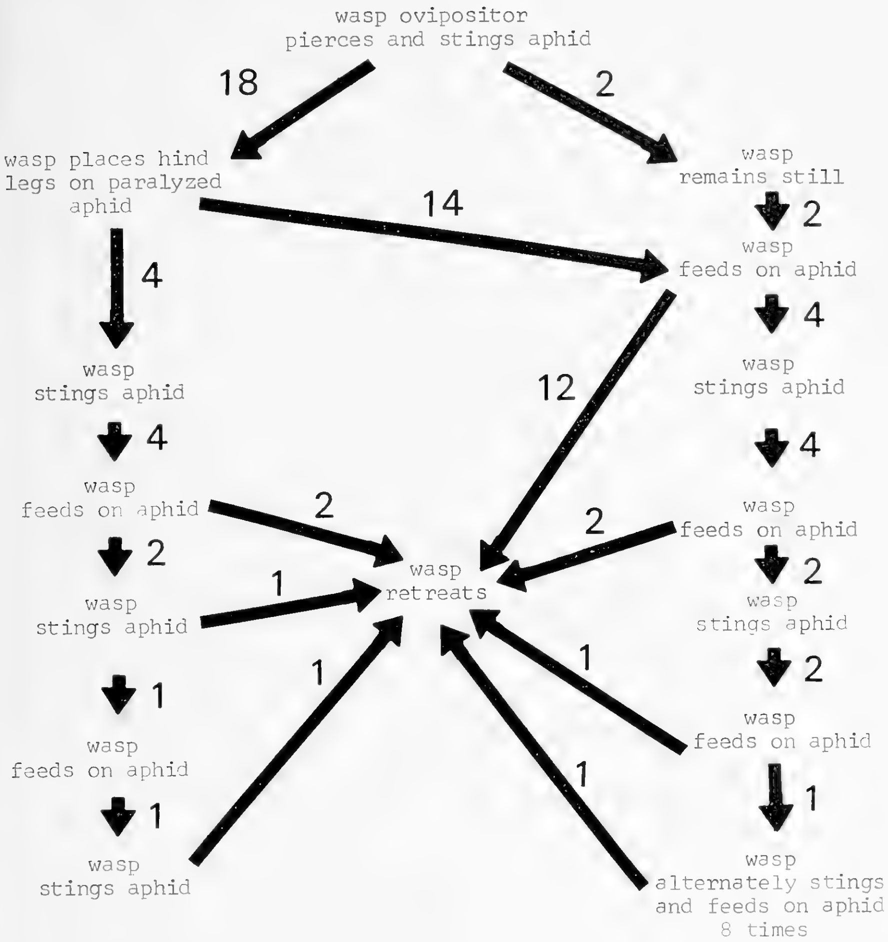

Fig. 3. Behaviors exhibited during first encounters of 20 different *Aphelinus asychis* with 20 different *Schizaphis graminum* during wasp stinging and feeding attacks on aphids. Numbers by arrows indicate frequencies of changes from one behavior (or sequences of behaviors) to another. See text for further explanation.

lyze aphids than to oviposit. Cate et al. (1973) reported that the initial sting of *A. asychis* lasted from 300–7,200 s, a much wider range than observed in our study. Hamilton (1973) reported that the average duration for stinging by *A. flavus* is 380 s.

After the initial paralyzing sting, most wasps fed and then retreated. Eight wasps, however, stung aphids one or more times after either feeding or being unsuccessful in finding sites of ovipositor insertion; these wasps alternated stinging attacks with feeding. These subsequent stinging attacks on the same aphids lasted from 39–821 s ($\bar{x} = 399$, $M = 330$). Statistical analysis suggests that initial stings were longer than subsequent stings ($T = 6$, $N = 8$, $p = 0.055$, *WMPT*). The average duration of all stinging attacks, both initial and subsequent, was 757 s.

Repeated and alternating stinging and feeding has been reported for *A. asychis* (Cate et al., 1973), *A. mytilaspidis* and *Tetrastichus xanthomelaenea* (Rond.) (Marchal, 1905). Initial stings made by *A. asychis* on aphids seemed to be sufficient to paralyze them and were significantly longer than subsequent stings on the same aphids. Marchal (1905) and Cate et al. (1973) also noted that repeated stings were often quite brief. Subsequent stings might serve to open other wounds in aphids or to enlarge existing wounds rather than to inject paralyzing agent into aphids.

Wasp initial feedings lasted from 141–1,815 s ($\bar{x} = 680$, $M = 978$, $N = 20$). Durations of subsequent feedings by 5 wasps were from 12–2,916 s ($\bar{x} = 1{,}083$, $M = 1{,}464$). The average duration of all feedings was 952 s. There was no statistical difference between durations of all stinging attacks and all feedings ($T = 83$, $N = 20$, $p > 0.05$, *WMPT*).

The paralyzing agent injected by wasps seemed to cause a number of changes in the appearance and behavior of stung aphids. These changes began to occur several minutes after ovipositor insertion. Usually, aphid abdomens swelled and raised, causing the aphid hind legs and occasionally the middle legs to be lifted off substrates. Hind legs waved in a weak, uncoordinated manner in the air. Waving became progressively slower and weaker until it eventually stopped.

At the same time, aphid antennae, which were usually held against dorsums, raised slightly and extended at various angles to aphid bodies. Aphids were usually prevented from falling by keeping their stylets embedded in *Sorghum* blades. In general, paralyzed aphids appeared completely to lose control of their movements, and they became immobilized and defenseless. Esmaili and Wilde (1972) reported similar changes in the appearance and activity of paralyzed *Schizaphis graminum.*

While wasps were feeding, aphid color changed from the usual green to yellow-green to yellow and finally to brown, a process which took from 20–45 min. The paralyzing agent, or substances introduced during wasps' feeding or both, might bring about this gradual color change, which was also noted by Cate et al. (1973) in the same host. When wasps finished feeding, aphids were shriveled and shrunken.

Wasps often had dark, flattened abdomens prior to host feeding. During feeding, however, abdomens swelled and became rounded and honey-colored. This process roughly corresponded to the gradual shriveling of aphids.

Dissection of 5 aphids that were fed upon *Aphelinus asychis* did not reveal any eggs deposited by wasps. Marchal (1909) and Esmaili and Wilde (1972) reported similar findings and stated that host feeding renders hosts unsuitable for oviposition. Full larval development of *A. asychis* in the dried, shrunken remains of fed-on aphids would seem difficult.

Aphid reaction to wasps.—Aphids reacted in a variety of ways and seemed to have some effective defense mechanisms against wasps. The most conspicuous defense reaction by aphids was "jerking." Aphids, with stylets embedded in *Sorghum* blades, quickly and forcefully flipped up their abdomens and lifted their hind and middle legs off the substrate. This was often done continuously for several minutes. Almost always, after one aphid began jerking, nearby aphids would also begin. A *Sorghum* blade often had several small groups of aphids in constant movement of this kind.

Other reactions of aphids included quickly extending antennae forward to touch wasps, crawling away from wasps and striking with legs at wasps.

Jerking, antennating, crawling away and kicking have been reported for several aphid species, including *Schizaphis graminum*, by Webster and Phillips (1912) and Hamilton (1973). These reactions seemed to have varying degrees of effectiveness as defense mechanisms depending on how soon they were initiated.

Jerking by S. *graminum* seemed to prevent attacks when it was initiated before or soon after wasps approached. Other aphids jerked after one started and this probably helped these other aphids from being attacked. This type of behavior was also noted by Hight et al. (1972).

Wasps apparently required or preferred stationary hosts, as they were never observed initiating attacks on aphids that were not still when they were approached. Jerking by aphids before wasps inserted ovipositors was usually effective in preventing contact because wasps seldom hit moving aphids with their ovipositors.

Aphid defense behaviors seemed to be stimulated by various kinds of wasp activity. On 5 occasions, groups of several aphids antennated a wasp and began jerking when the wasp walked past the aphids, they did not touch or give any noticeable indication of attacking them. On 29 occasions, wasps, which approached aphids and appeared about to attack them, seemed to provoke reactions from aphids which seemed to cause wasps to retreat without attacking. These reactions were all of the types mentioned above.

Although many aphids showed no noticeable reaction to ovipositional attacks, some aphids jerked strenuously after being pierced. Once jerking was initiated, it usually continued for several minutes, even after wasps retreated. Jerking after wasps inserted ovipositors seemed to have little or no effect on the outcome of the attacks, either ovipositional or stinging attacks. Aphids often completely lifted wasps off the substrate, but wasp ovipositors remained in the aphids and wasps remained as still as possible, never raising antennae until just prior to retracting ovipositors.

The most violent and prolonged reactions by aphids were caused by wasp stinging attacks. In every stinging attack observed, aphids began jerking violently within from 2–5 min after ovipositor insertion. Aphids continued violent, strenuous movement for several minutes until they gradually began to show signs of paralysis. Frequently, aphids twisted around, using their stylets embedded in *Sorghum* as pivots. In 8 stinging attacks, aphids removed stylets from *Sorghum* and rapidly walked away, dragging wasps with them. Wasps were never dislodged by these activities, although they were often dragged several centimeters or flipped over.

Alarm behavior was observed during 4 stinging attacks; immediately after a stung aphid began jerking, all nearby aphids withdrew their stylets from *Sorghum* and quickly scattered. On 3 occasions, stung aphids jerked violently and produced yellowish droplets from the tips of both cornicles, after which all nearby aphids began jerking and then scattered. An alarm pheromone in the cornicle secretions of *Schizaphis graminum* and other aphids was demonstrated by Bowers et al. (1972) who identified the active substance as trans-B-farnesene. Kislow and Edwards (1972) noted interspecific reactions to the pheromone which is detected by sensoria located on aphid antennae (Nault et al., 1973). Aphid cornicle secretion is considered a self-serving and altruistic defensive system by Nault et al. (1976).

One wasp placed her right foreleg in a cornicle droplet while she was feeding, and the droplet apparently hardened around her leg. The wasp struggled for about 45 min before freeing herself. This has also been noted by Edwards (1966) who found cornicle secretions to be lipid droplets in water that rapidly crystallizes when in contact with a solid surface. Edwards (1966) found only 2 wasps entrapped in secretions produced by several thousand aphids; Goff and Nault (1974) never observed wasps entrapped by cornicle secretions. Our study also suggests that cornicle secretions rarely entrap wasps.

Schizaphis graminum probably detect approaching *Aphelinus asychis* partly through vision. Dixon (1958; 1973) stated that aphids would be at an advantage when predators approached from the front because they could be seen more easily. This study supports Dixon's supposition because although more wasps approached aphids from the front, frontally approached aphids often reacted defensively, and a larger percentage of rear approaches preceded oviposition.

Schizaphis graminum probably also use tactile perception to detect wasps. Aphids which did not show any other reaction to wasp often jerked only after wasps pierced them. This did not seem to affect the outcome of the attacks, but it often caused nearby aphids to begin jerking.

Additional observations.—Two variations of behavior associated with ovipositional attacks were occasionally observed. Five wasps approached single aphids, stopped and briefly antennated them. Then, instead of swaying, they lowered their antennae and quickly butted the fronts of their heads against the aphids. Two wasps butted aphids once, and 3 wasps made 2 such charges in rapid succession. All wasps then continued with the usually observed sequence of turning, everting ovipositors and stabbing at aphids. Wasps exhibiting this type of behavior appeared to move more quickly and to take less time antennating aphids than other wasps, and in general, appeared more agitated than usual.

Five other wasps "attacked" either cast skins of aphids (2 wasps), aphid eggs (2 wasps) or a spot on a *Sorghum* blade where an aphid had recently been feeding (1 wasp). In all cases, the wasps showed the usual behavioral sequence prior to ovipositor eversion. One wasp made a SE and then retreated. All others made from 3–14 eversions before retreating.

Factors that initiate attacks probably includes wasps' motivation to either oviposit or feed and stimuli from aphids, e.g., odors, sizes, shapes. Wasps that are highly motivated to attack probably do so at lower stimulus thresholds than wasps that are less highly motivated (Sekhar, 1957). This may explain wasp attacks on aphid skins, eggs and a recently vacated feeding site. Each of these objects may have carried sufficient aphid odor, had other characteristics or both, to stimulate highly motivated wasps to attack. Similar wasp behavior has been reported for *Aphelinus nigritus* (Webster and Phillips, 1912) and *Tetrastichus flavigaster* (Moran et al., 1969).

Wasps butting their heads against aphids rather than swaying prior to turning and everting ovipositors might also be a reflection of the motivational state of the wasps. Swaying often consumed several seconds and, as noted, was often interrupted several times while wasps remained motionless. Wasps that are highly motivated to attack may have eliminated this relatively time-consuming behavior and replaced it with a far more rapid action.

Acknowledgments

The authors thank Roger D. Eikenbary (Oklahoma State Univ.) for providing *Sorghum* seeds and live specimens of *Aphelinus asychis*; Robert Schroeder (SEA, USDA) for providing *Schizaphis graminum*; Donald M. Spoon (Georgetown Univ.) for making available photographic supplies and facilities; and Gordon Gordh (formerly SEA, USDA) for encouraging this study, reading a draft of this paper and making numerous helpful suggestions. Lawrence S. Oliver (Georgetown Univ.) also made important suggestions regarding a preliminary draft of this paper. The first author gives special thanks to Irving Gray (Georgetown Univ.), Roger Cressey (Smithsonian Institution), and the late Beulah Howatt McGovern (Dunbarton College) for their help and encouragement. Janice B. Browne helped with the preparation of the manuscript.

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Department of Biology, Georgetown University, Washington, D.C. 20057 (HB mail address: 313-A Broad Run Drive, Sterling, Virginia 22170).

BOOK REVIEW

Taxonomic Study of the Cicadellinae (Homoptera: Cicadellidae). Part 2. New World Cicadellini and the genus Cicadella. David A. Young. 1977. 1135 pp., 905 figs. North Carolina Agricultural Experiment Station Technical Bulletin 239. Available for $15. (post paid) from Publications, 318 Ricks Hall, North Carolina State University, Raleigh, North Carolina 27607.

This is the 2nd of 3 volumes of the most ambitious and comprehensive taxonomic revision ever attempted on a world-wide basis for a large portion of the family Cicadellidae, itself one of the largest families of the Insecta. Part 1, Proconiini (1968. U.S. Nat. Mus. Bull. 261, 287 pp.) together with Part 2 complete the subfamily for all of the Americas. Part 3, now in preparation, will treat all of the Old World species.

The Cicadellini, especially in the Neotropics, comprises many species with bright and striking color patterns. Early describers, often in scattered and usually unrelated works, had field days with descriptions of hundreds of new species. No one before Dr. Young was really successful in bringing together and integrating all of the taxonomic data concerning the New World Cicadellini within a lifetime; although Signoret (1816–1889) and Melichar (1856–1924) made partial efforts toward this goal.

Within the present work, Dr. Young provides keys and descriptions for 155 genera, of which 91 are new. He recognizes over 1,100 valid species, of which 390 are new. The keys to genera and species use characters which are well illustrated in the text by over 900 figures or line drawings. Treatment of the previously described species is frugal but highly adequate. The 1,135 pages of this volume are entirely free of extraneous matter. In fact, the format is a model of excellence, one in which the data are concentrated and concise.

In order to truly appreciate the author's magnificent effort, one must be familiar with the confusion and uncertainty in almost all of the past literature dealing with hundreds of species from Central and South America. Dr. Young has established both a solid classification upon which others can build in the future and a system for identification which can be used today by those concerned with plant-feeding insects. Simply stated, this is the most outstanding and comprehensive single volume ever produced on a large segment of the Cicadellidae.

James P. Kramer, *Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560.*

SOCIETY MEETINGS

844th Regular Meeting—6 October 1977

The 844th Regular Meeting of the Entomological Society of Washington was called to order by President-Elect Sutherland at 8:05 PM on 6 October 1977 in the Ecology Theater of the National Museum of Natural History. Thirty-six members and 9 guests were present. The minutes of the April meeting were read and approved.

Membership Chairman Utmar read for the first time the names of the following new applicants for membership:

W. Nelson Beyer, Patuxent Wildlife Research Center, Laurel, Maryland.
Jack L. Boese, 900 Madison Ave., Baltimore, Maryland.
LeMar M. Chilson, 2016 Seattle Ave., Silver Spring, Maryland.
T. P. Copeland, East Tennessee St. Univ., Johnson City, Tennessee.
James H. Kennedy, 105 Tee St., Blacksburg, Virginia.
Brian R. Pitkin, Dept. of Entomology, British Museum (Natural History), Cromwell Road, London.

President Ramsay was excused due to illness.

Editor Stoetzel announced that Former President George Steyskal's "Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae)" was recently published by the Society and is on sale for $1.50/copy. She also announced that the October issue of the *Proceedings* will be about 166 pages and asked the membership for any comments concerning the new format. Based on the first issue using the new format, the Society saved about 6%.

President-Elect Sutherland reported that the audit and nominating committees will be appointed soon. He also announced that Mr. Muesebeck, a Past President and long-time supporter of the Society had made a considerable donation to the special publications fund.

Don Davis called attention to the new Naturalists Center of the Museum. He explained the function of the Center, which is to help serious amateurs, and suggested that the Society might want to hold a meeting there and help with the entomology section.

Joyce Utmar discussed briefly the Maryland Center for Systematic Entomology. Don Messersmith further commented on the new program, which is a cooperative effort by scientists of the USDA, Smithsonian and the University of Maryland to provide training in systematics.

The main speaker for the evening was Dr. David Inouye, Assistant Professor of Zoology, University of Maryland. Dr. Inouye spoke on coevolution between ants and plants. After reviewing examples from tropical climates, Dr. Inouye described his research on three species of temperate

Helianthella (Asteraceae) and *Formica* ants. The presentation was illustrated by many excellent Kodachrome slides and was followed by a lively question and answer period.

Notes and Exhibitions

Manya Stoetzel reviewed a new book entitled "Survey of the World Aphids" by V. F. Eastop and D. Hille Ris Lambers.

Chris Thompson showed slides of a recent trip to Europe, particularly of the Paris and Vienna Museums.

Helen Sollers-Riedel announced that the new Mosquito Catalogue by Ken Knight and Alan Stone was recently published and Doug Sutherland showed a copy of Richard Foote's new "Thesaurus of Entomology."

Several visitors were introduced.

The meeting was adjourned at 9:17 PM, after which cider and cookies were served.

Wayne N. Mathis, *Recording Secretary*

845th Regular Meeting—3 November 1977

The 845th Regular Meeting of the Entomological Society of Washington was called to order by President Ramsay at 8:00 PM on 3 November 1977 in the Ecology Theater of the National Museum of Natural History. Twenty-three members and 7 guests were present. The minutes of the June and October meetings were read and approved.

Acting Membership Chairman Spilman read for the first time the names of the following new applicants for membership:

Daniel F. Austin, Dept. Biol. Sci., Florida Atlantic University, Boca Raton, Florida.

Joaquin Bueno-Soria, Instituto de Biologia, U.N.A.M., Apartado Postal 70-153, Mexico 20, D.F. Mexico.

Michael E. Faran, MEP/NHB 165, Smithsonian Institution, Washington, D.C.

President Ramsay thanked President-Elect Sutherland for presiding and conducting while he was ill.

Ted Spilman reminded the membership that dues envelopes were included with the October issue of the *Proceedings*, and he encouraged the membership to use them. Mignon Davis suggested that a "double" membership category be created for spouses of members. Ted Spilman suggested that the Executive Committee consider such memberships.

Editor Stoetzel brought copies of George Steyskal's pictorial key to the species of *Anastrepha* and copies of the October issue of the *Proceedings* for anyone interested.

Nominating Committee Chairman Steyskal announced the new slate of Society officers as follows:

President-Elect	Donald R. Davis
Recording Secretary	Wayne N. Mathis
Corresponding Secretary	Donald R. Whitehead
Treasurer	F. Christian Thompson
Editor	Manya B. Stoetzel
Custodian	Sueo Nakahara
Program Chairman	Victor E. Adler
Membership Chairman	Joyce A. Utmar

The nominating committee included Chairman George C. Steyskal, Richard Newkirk and Donald Messersmith.

With the approval of Helen Sollers-Riedel, it was moved, seconded, and unanimously approved that she continue as Hospitality Chairwoman.

Lee Hellman introduced the main speaker for the evening, Dr. F. E. Wood, Associate Professor, Department of Entomology, University of Maryland. Dr. Wood spoke on "New Views on Human Lice." Dr. Wood explained how he first became interested in the problem of human head lice on school children and discussed the results of his research. He noted that head lice are not found on black children, probably due to the flat structure of their hair which makes attachment of the nit to the hair strand less effective. He also presented several sources of evidence which suggest that the head and body louse are two species. Dr. Wood illustrated his talk with several slides and entertained an interesting question and answer session afterwards.

President Ramsay noted that the forthcoming Congress of Plant Protection would be held in Washington, 5–12 August 1979.

At the suggestion of Ashley Gurney, it was moved and seconded that the Society further acknowledge the generous contribution of Mr. Muesebeck with a standing vote of thanks, which followed.

Notes and Exhibitions

Curt Sabrosky announced that the large and valuable collection of Muscidae and Anthomyiidae of Dr. H. C. Huckett was recently donated to the Smithsonian. Don Davis announced that the Society could use the facilities of the Museum's Naturalists Center for the first meeting of 1978 (January 5th).

Ashley Gurney projected and discussed about 35 Kodachrome pictures of local insects and spiders, also of scenic outdoor areas in Chile and southern Argentina which he visited in December 1976. The latter included chiefly scenes in national parks in that part of Patagonia near Bariloche, Argentina.

John H. Fales reported the collecting of *Staphylus hayhurstii* (Edwards) (Hesperiidae) at two locations in Rock Creek Park, Washington, D.C. on 31 August and 8 and 12 September 1977. These are probably the first occurrences of this species in the District of Columbia.

The meeting was adjourned at 9:34 PM, after which punch and cookies were served.

Wayne N. Mathis, *Recording Secretary*

846th Regular Meeting—1 December 1977

The 846th Regular Meeting of the Entomological Society of Washington was called to order by President Ramsay at 8:00 PM on 1 December 1977 in the Ecology Theater of the National Museum of Natural History. Thirty-five members and 31 guests were present. The minutes of the November meeting were read and approved.

Because of the large number of guests, President Ramsay asked all attending to briefly introduce themselves.

Membership Chairman Utmar reported that 34 new memberships were accepted in the Society during 1977. She also read for the first time the name of the following new applicant for membership:

Norman Lin, 1487 E 37 St., Brooklyn, New York.

Treasurer Thompson and Editor Stoetzel gave their annual report to the Society. Both reports will appear in the April issue of the *Proceedings.*

President Ramsay introduced the main speaker for the evening, Dr. Larry Rockwood, Department of Biology, George Mason University, who spoke on "Howling Monkeys and Leaf-Cutting Ants: Comparative Foraging in a Tropical Deciduous Forest." Dr. Rockwood reviewed the biology of the leaf-cutting ant (*Atta columbica*) and of the Howling Monkey (*Alouatta palliata*) and noted that both are general herbivores but that feeding preferences change during the dry and wet seasons. Dr. Rockwood illustrated his talk with several Kodachrome slides and led an interesting question and answer period afterwards.

Notes and Exhibitions

President Ramsay noted that a former student from Japan, Dr. Akira Kamito, commemorated his 77th birthday with a special publication, entitled: "Studies on the broad bean weevil, *Bruchus rufimanus* Boheman with special reference to its bionomics and control."

Nominating Committee Chairman Steyskal read the slate of proposed new officers for 1978. President Ramsay asked if there were any nominations from the floor. It was then moved and seconded that the slate be adopted as announced, which was unanimously accepted by the vote of the Society.

President Ramsay turned the gavel over to President-Elect Sutherland.

President Sutherland thanked the Society for their support and adjourned the meeting at 9:35 PM after which punch and cookies were served.

Wayne N. Mathis, *Recording Secretary*

847th Regular Meeting—5 January 1978

The 847th Regular Meeting of the Entomological Society of Washington was called to order by President Sutherland at 8:00 PM on 5 January 1978 in the Naturalists Center of the National Museum of Natural History. Twenty-seven members and 12 guests were present. The minutes of the December meeting were read and approved.

Membership Chairman Utmar read for the first time the names of the following new applicants for membership:

David W. Brassard, 8304 Tobin Rd., Annandale, Virginia.
David G. Casdorph, P.O. Box 1458, Monrovia, California.
William H. Gotwald, Jr., Dept. of Biol., Utica College of Syracuse University, Utica, New York.
George F. Ludvik, 9113 Rockefeller Lane, Springfield, Virginia.

Past President Ramsay noted that the Society has no certificate of membership or officership. After a brief discussion, it was suggested that any proposal for certification be floored after consideration by the executive committee.

President Sutherland announced that Maynard J. Ramsay will retire this month after 34 years of federal service. A retirement luncheon will be given 13 January at 11:30 AM at the Royal Arms Restaurant, Hyattsville, Maryland.

The traditional Past President's address was given by Maynard J. Ramsay of the National Program Planning Staff, APHIS, USDA. His topic was "Exotic Pest Detection and Evaluation—A Regulatory Agency's Dilemma." He showed a training film for new recruits to APHIS entitled: New Pest Detection and Information Program," explaining the national pest survey teams' work in discovering new pests, especially in corn, soybeans, small grains, forage and citrus crops. The Agency has two functions:

1. The survey and detection of pests.
2. The action/no action decision making after a new pest has been discovered.

Ramsay illustrated his remarks after the film with several slides and charts. A question and answer session followed.

Notes and Exhibitions

Don Davis explained the function of the Naturalists Center, the room in which our meeting was held. This new facility at the museum is a place for serious amateurs to browse through collections of natural history specimens to enable them to identify their own collections or to do research on hobbies, etc. Collections of specimens of mostly local species were assembled by members of the museum staff and many other specimens, books, and equipment were donated by others.

T. J. Spilman showed a colored lithograph of passalid beetles anthropomorphically playing a game of pool. The origin of the picture had been traced, with the help of R. D. Pope, to Theodor Compton, illustrator of Kaup's 1871 monograph of the passalids in Berliner Entomologische Zeitschrift.

C. W. Sabrosky announced the death on 21 November of Boris B. Rohdendorf, a worker on fossil insects and sarcophagid flies.

Helen Sollers-Riedel showed a book on insect flight, *Borne on the Wing*, by Steven Dalton.

John H. Fales showed special first day cover stamps featuring four Lepidoptera prepared by the Maryland Entomological Society and gave some information on that Society.

Finally, C. W. Sabrosky suggested that any books or other exhibitions be passed around before the main speaker's talk so everyone gets a chance to see them.

The meeting adjourned at 9:33 PM, afterwhich punch, cookies, and cake were served.

Joyce Utmar, *Acting Recording Secretary*

848th Regular Meeting—2 February 1978

The 848th Regular Meeting of the Entomological Society of Washington was called to order by President Sutherland at 8:00 PM on 2 February 1978 in the Ecology Theater of the National Museum of Natural History. Twenty-nine members and 5 guests were present. Minutes of the January meeting were read and approved.

Membership Chairman Utmar read for the first time the names of the following new applicants for membership:

Antonio Paulo Assis de Moraes, Acacia Ct., Mission Viejo, California 92675.

Richard Duffield, Department of Biology, Howard University, Washington, D.C. 20059.

Michael Kosztarab, Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Roy A. Norton, Department of Environmental and Forest Biology, College of Environmental Science and Forestry, State University of New York, Syracuse Campus, Syracuse, New York 13210.

Durward D. Skiles, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California 90024.
Greg Spicer, 405 Cedar Creek Ct., Fort Worth, Texas 76103.

Announcement was made of our Annual Banquet, to be held at the Ft. McNair Officers Club, 4th and P Sts., Washington, D.C., members attending as guests of Dr. Dale W. Parrish.

The Washington, D.C. Science Fair requested members to assist in judging exhibits at the 18 March Science Fair.

Exhibitions

John Horne displayed a mulberry stake from his tomato garden, showing vespid wasps which had bored 1½ feet in the twig.

The main speaker of the evening was Dr. David Stiller, Animal Parasitology Institute, ARS, Beltsville, MD, who spoke on "Entomological studies in Malaysia." In a travelogue section, he noted the diversity of cultures of the people inhabiting Malaysia, then spoke on his research. Included were studies of the humidity requirements of the ticks *Dermacentor atrosignatus* and *Hemaphysalis semiermis*, ticks of a monitor lizard, lung mites of snakes, and lung mites of the silvered leaf monkey. Attempts were made to find a suitable alternate host for laboratory study of treatment of these lung mites. The mites also affect *Rhesus* monkeys, widely used in research. There is presently no treatment for this infestation. Dr. Stiller's talk was illustrated with many Kodachrome slides. Question and answer session followed.

Notes

Ashley B. Gurney reported on his research on the history of stereoscopic microscopes of the 1890's and early 1900's, especially those made by Zeiss in Jena, Germany.

The meeting was adjourned at 9:35 PM, after which punch and cookies were served.

Joyce A. Utmar, *Acting Recording Secretary*

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld	3.00
Both papers on cynipid galls	6.00
Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	.25
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver	.25
A Short History of the Entomological Society of Washington, by Ashley B. Gurney	.50
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal	1.50

Memoirs of the Entomological Society of Washington

No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 1942	15.00
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 1976	11.00

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PROCEEDINGS
of the
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**DEPARTMENT OF ENTOMOLOGY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C. 20560**

PUBLISHED QUARTERLY

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THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

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MEETINGS.—Regular meetings of the Society are held in the Ecology Theater, Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 8 P.M. Minutes of meetings are published regularly in the *Proceedings.*

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The Society does not exchange its publications for those of other societies.

Please see inside back cover of any 1972–1975 issue for instructions regarding preparation of manuscripts.

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A SYNOPSIS OF NEOTROPICAL *ELELEIDES* CRESSON (DIPTERA: EPHYDRIDAE)

Wayne N. Mathis

Abstract.—A synopsis of Neotropical *Eleleides* is presented and includes a key to all species, appropriate figures, description of a new species (*E. penai*), distributional notes on *E. liroceras* and a general discussion of the genus. *Eleleides liroceras* and *E. penai* are shown to be sister-species. The former is newly described from Chile (type-locality: Anticura, Osorno Province) and fulfills an earlier prediction that additional members of *Eleleides* would be found in western South America. The known distribution of *E. liroceras* is increased to southern Brazil (Nova Teutonia) and southern Chile (Lampa and Anticura).

Since the revision of *Eleleides* Cresson by Mathis (1977), additional specimens of both *E. liroceras* Mathis and a new species have become available. The new species is the third to be described in *Eleleides* and the second from South America. The purpose of this paper is to report these discoveries and to comment on the distribution and relationships of the species. The methods used are those of my earlier revision, particularly the descriptive portions which follow the same format as used previously.

The new specimens of *E. liroceras* were collected in the state of Santa Catarina, Brazil, and in the provinces of Osorno and Santiago, Chile, which substantially increases the known distribution of that species. Likewise, the occurrence of a second Neotropical species on the west slope of the Andes Mountains is an important discovery. Not only does the distribution of the genus now appear more plausible, but the new species partially fulfills an earlier prediction that other members of the genus are likely to be found in western South America (Mathis, 1977).

Key to species of *Eleleides* Cresson

1. Third antennal segment and maxillary palp black; eye-to-cheek ratio less than 1:0.25; 1 or more pairs of larger acrostichal setae in addition to prescutellar acrostichal pair; supra-alar seta well developed, at least ½ length of postalar seta (Australia) *E. chloris* Cresson

– Third antennal segment and apex of maxillary palp orange to yellowish orange; eye-to-cheek ratio more than 1:0.40; all acrostichal setae except for prescutellar acrostichal pair uniform in size, small; supra-alar seta lacking or greatly reduced 2

2. Tibiae yellowish orange, concolorous with basitarsi; mesopleuron completely silvery gray, pollinose, contrasting distinctly with bronze-colored mesonotum; abdominal terga usually with pollinose grayish wedges extending dorsally from ventral margins (Argentina, Brazil and Chile) *E. liroceras* Mathis

– Tibiae mostly black, concolorous with femora; mesopleuron mostly brown to bronze colored, concolorous with mesonotum; abdominal terga unicolorous or at most slightly grayish along ventral margins (Chile) *E. penai*, new species

Eleleides liroceras Mathis
Fig. 4

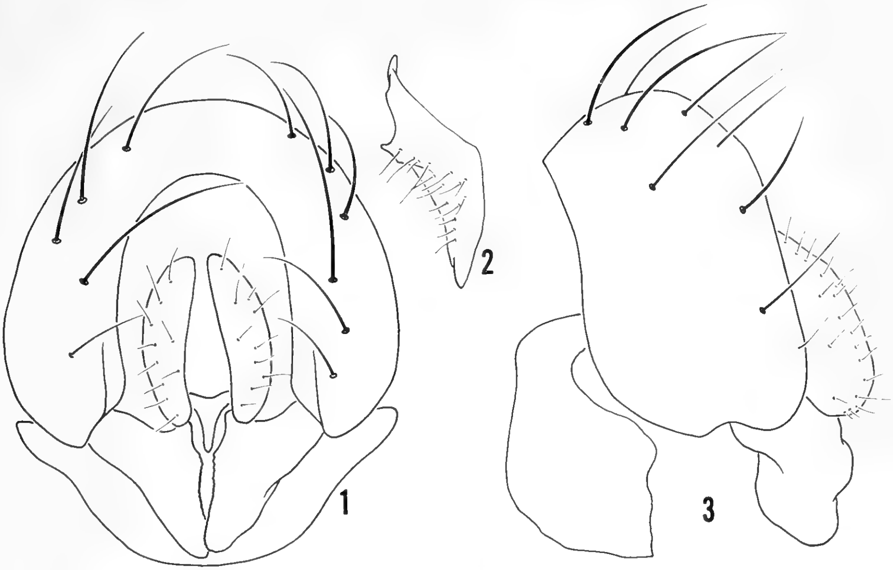
Eleleides liroceras Mathis, 1977:560 (figures of head, thorax, wing, and male genitalia).

Remarks.—When this species was described, specimens were available only from the type-locality, Hurlingham, Buenos Aires, Argentina. I have now examined five additional specimens as follows: Brazil: Santa Catarina, Nova Teutonia (27°11'S, 52°23'W), Sept. 1970, Fritz Plaumann (2♀, MZUSP). Chile: Osorno Province, Anticura (1 km W.), 1–3 Feb. 1978, W. N. Mathis (1♀, USNM). Santiago Province, Lampa (22 km N. Santiago), 21 Jan. 1978, W. N. Mathis (2♂, USNM). Although I am confident that these specimens are conspecific with those from the type-series, males were available only from the Lampa locality for confirmation.

Based on the locality data now at hand, I would expect to find specimens of this species throughout the *Araucaria* zone of southern South America where sedge-meadow habitats exist.

Eleleides penai Mathis, new species
Figs. 1–4

Diagnosis.—Specimens of *E. penai* are distinguished from those of both congeners by the following combination of characters: Third antennal segment pale, yellowish orange to orange; frons mostly pollinose, grayish-bronze colored, except for subshiny vitta extending from median ocellus to ptilinal suture; maxillary palp pale, yellowish orange on apical ½ to ⅔; eye-to-cheek ratio more than 1:0.40; mesonotum pollinose to subshiny, mostly bronze colored, becoming grayer toward lateral margins, scutellum and posterior portion of mesonotum not distinctly darker in color; bristles in general more strongly developed; no larger pairs of acrostichal bristles except for prescutellar pair; supra-alar seta reduced greatly or lacking; mesopleuron mostly brown to bronze colored, concolorous with mesonotum and contrasting distinctly with silvery-gray color of notopleuron; tibiae



Figs. 1–3. *Elcleides penai.* 1, Epandrium, cerci, surstyli and hypandrium, posterior aspect. 2, Anterior surstylus, lateral aspect. 3, Epandrium, cerci, surstyli and hypandrium, lateral aspect.

dark, grayish black to black, concolorous with femora; abdominal terga lacking distinct grayish wedges extending dorsally from ventral margins, at most slightly grayish along ventral margin.

Description.—Length 2.36 to 2.97 mm (averaging 2.66 mm).

Head: Head width-to-height ratio averaging 1:0.79; frons width-to-length ratio averaging 1:0.61; frons subshiny, black with dense bronzish-brown pollinose vestiture, pollinosity becoming weaker anteriorly; frontal vitta between median ocellus and ptilinal suture, subshiny, becoming narrower anteriorly, bronze colored; fronto-orbital plate slightly raised in relief from remainder of frons. First and 2nd antennal segments black, mostly dull; 3rd segment slightly longer than wide, mostly pale, yellowish orange to orange, becoming darker along dorsal edge in some specimens, macropubescent along rounded apical edge. Face and gena concolorous, silvery gray, densely pollinose to tomentose, face height-to-width ratio averaging 1:0.67; clypeus black, with pollinose vestiture less dense than face; maxillary palp pale on apical ½ to ⅔, yellowish orange, concolorous with 3rd antennal segment, becoming darker, brownish black basally. Eye height-to-width ratio averaging 1:0.90; eye-to-cheek ratio averaging 1:0.43; ventral portion of gena with a shallowly impressed groove running parallel with edge.

Thorax: Black, covered with pollinose vestiture; mesonotum mostly dull anteriorly, becoming subshiny posteriorly, brown to bronze colored, becoming grayer anteriorly and laterally; humerus and notopleuron concolorous, gray, contrasting distinctly with mesonotum; mesopleuron and pteropleuron concolorous mostly grayish bronze, posterior margins gradually becoming grayer; propleuron, front coxa, sternopleuron and hypopleuron nearly concolorous, mostly gray to silvery gray, becoming slightly darker posteriorly. Femora and tibiae of all legs concolorous, subshiny to pollinose, bronzish black, base and apex of tibiae paler, yellowish; basitarsus of each leg pale, yellowish; other tarsomeres becoming darker apically, apical ones mostly black. Wing entirely hyaline; wing length-to-width ratio averaging 1:0.44; costal vein ratio averaging 1:0.50; M_{1+2} vein ratio averaging 1:0.80; posterior crossvein perpendicular with vein M_{1+2}. Halter pale, capitellum white, pedicel yellowish.

Abdomen: Subshiny to shiny dark metallic bronzish-black coloration; some specimens with ventral margin of each tergum slightly more pollinose, grayish. Male terminalia as follows (Figs. 1–3): Posterior surstylus triangular in posterior aspect, medium edge crenulate to serrate, with medioposterior enlargement in lateral aspect, wider dorsally; anterior surstylus with anterior margin setose, posterior margin angulate; epandrium 2× as wide as high, narrowing ventrally. Female ventral receptacle similar to that of *E. liroceras* (Figs. 6–7, Mathis, 1977).

Type-material.—Holotype ♂, labelled: "CHILE: Osorno Pr. Anticura (1 km W) 432 m elev. 1–3 Feb. 1978 WNMathis." Allotype ♀ and 2 paratypes (1♂, 1♀; USNM): with same locality data as the holotype; dates from 3–6 February 1978. Other paratypes as follows: CHILE: Santiago Province: El Alfalfal, 22 Jan 1978, W. N. Mathis (1♂, 2♀; USNM); Coquimbo Province: El Naranjo, Tilama, October 1967, L. E. Peña (1♂, 4♀; MZUSP). Chiloe Province: Chepu, April 1968, L. E. Peña (1♀; MZUSP). The holotype is in the National Museum of Natural History Smithsonian Institution, Washington, D. C., (USNM type-number 75764).

Geographic distribution (Fig. 4).—Specimens were examined from four localities in Chile between 32° and 42° south latitude. This distribution substantiates an earlier prediction (Mathis, 1977) that other members of the genus would be discovered in western South America.

Natural history.—All specimens taken by me were collected in sedge-meadow habitats. The surrounding environs of each sedge-meadow habitat varied considerably from scrub-covered foothills southeast of Santiago (El Alfalfal) to *Nothofagus* forests (Anticura) in the Lake district of southern Chile.

Etymology.—The species epithet, *E. penai*, is a genitive patronym honoring Luis E. Peña G., J. I. Molina Institute, who collected part of the type-

Fig. 4. Distribution map of *E. liroceras* and *E. penai.*

series and who graciously hosted me in Chile while I collected the remainder.

Relationships.—This species and *E. liroceras* are sister-species. This relationship is corroborated by numerous synapotypies as indicated in Fig. 5 and Table 1.

General Discussion

Although the distribution of *Eleleides* remains disjunct, the discovery of an additional species in western South America and of the extended range of *E. liroceras* substantiates their south temperate distribution. Still, I am of the opinion that more members of the genus will yet be found and suggest that South Africa or New Guinea will be productive in this regard.

The distribution of *Eleleides* species in South America is not related to

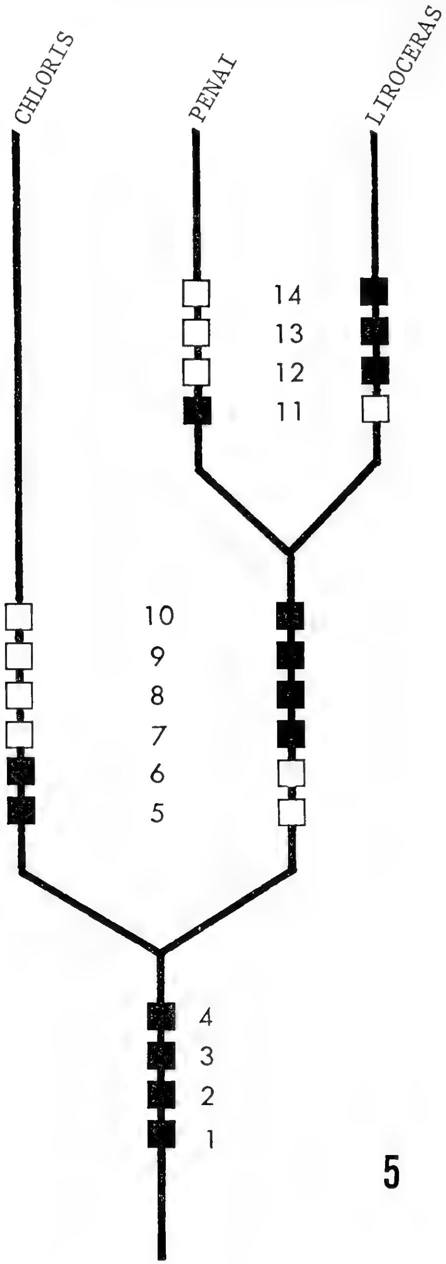


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Fig. 5. Argumentation scheme for the hypothetical phylogeny of the genus *Eleleides*. Filled squares = apotypic character states; open squares = plesiotypic character states.

Table 1. Character and character states used in the phyletic analysis of the species of *Eleleides*.

CHARACTER	Character States	
	Apotypic	Plesiotypic
1. Dorsal branches of arista	few, 5 or fewer	many, 7 or more
2. Orientation of largest fronto-orbital seta	posterolateral, oblique	proclinate
3. Size of supra-alar seta	smaller than postalar seta	as large or larger than postalar seta
4. Shape of ventral margin of face	emarginate, arched	flat
5. Size of acrostichal setae	1 larger pair of sutural setae	all subequal
6. Facial vestiture	mediodorsal portion partially bare, subshiny	uniformly pollinose
7. Coloration of 3rd antennal segment	pale, yellowish orange	dark, concolorous with first and second segments
8. Eye-to-cheek ratio	large	small
9. Supra-alar seta	absent	present
10. Coloration of maxillary palp	pale, yellowish orange	dark
11. Coloration of mesopleuron	concolorous with mesonotum	vestiture much lighter than mesonotum
12. Coloration of tibiae	pale, yellowish	dark, concolorous with femur
13. Symmetry of aedeagus	asymmetrical	symmetrical
14. Coloration and vestiture of ventral margins of abdominal terga	grayish, pollinose wedges extending dorsally from ventral margin	concolorous with remainder of terga or at most with slightly grayish margin ventrally

conventional biogeographic provinces used to partition that continent (Cabrera and Willink, 1973). This is evident from the distribution of either species. The distribution of *E. liroceras*, for example, includes four of Cabrera and Willink's biogeographic provinces: Paranense, Pampeana, Chilena and Subantartica. The Paranense and Pampeana provinces are adjacent, along the east coast near the Parana and La Plata Rivers, but the Subantartica and Chilena provinces are far removed, being situated along the western slope of the Andes Mountains. Likewise, *E. penai* is known to occur in more than one biogeographic province in western South America. What seems to be more important to the distribution of *Eleleides* is the occurrence of aquatic systems, almost without regard to the surrounding habitat. Where sedge-meadow habitats occur in temperate South America, it is likely that specimens of *Eleleides* will also be found there.

The widespread distribution of *Eleleides* species also indicates that the species of *Eleleides* are probably not closely associated with a particular plant species. The biogeographic provinces, as defined by Cabrera and Willink (1973), are based primarily on the distribution of plants; and, because the distribution of *Eleleides* species broadly overlaps these, the likelihood of a specific plant association seems remote.

The relationships among species of *Eleleides* is summarized in Fig. 5 and the accompanying list of character evidence (Table 1). The numbered squares refer to the list of character states on the table.

Acknowledgments

I am grateful to Mr. Luis E. Peña G. for his assistance while collecting in Chile and to Dr. Nelson Papavero (Museu de Zoologia da Universidade de Sao Paulo, MZUSP) for hosting me in Brazil and for the loan of *Eleleides* specimens. For financial assistance through a fluid research grant, I thank Mr. S. Dillon Ripley, Secretary of the Smithsonian Institution. For critical review and constructive commentary of this paper, I thank Dr. Paul J. Spangler.

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Department of Entomology, NHB 169, Smithsonian Institution, Washington, D.C. 20560.

PROC. ENTOMOL. SOC. WASH.
80(4), 1978, pp. 473–484

A NEW GENUS AND TWO NEW SPECIES OF EOSENTOMOIDEA (PROTURA: EOSENTOMIDAE)

T. P. Copeland

Abstract.—The genus *Styletoentomon* is erected and two new species are described, *Styletoentomon styletum* and *Eosentomon erwini. Eosentomon rostratum* Ewing is moved to *Styletoentomon.*

Until 1974 the suborder Eosentomoidea contained only the family Eosentomidae with a single genus, the *Eosentomon.* Tuxen (1964) in his monumental work made provisional groupings within the genus on the basis of the female squama genitalis but without setting them up as genera. In 1974, Yen described an eosentomid without spiracles from China and established a second genus, *Antelientomon,* to contain it. Tuxen (1975) erected *Isoentomon,* a third genus, to contain several species with spiniform foretarsal sensilla e and g. In 1977, Yen erected a fourth genus within the Eosentomoidea, *Anisentomon,* from China. There still remains well over a hundred species within the original genus, *Eosentomon.* All species in the four genera have chewing-type mandibles each possessing three to several small apical teeth except for *Eosentomon rostratum* Ewing (1940) and the one described herein both of which have stylet-shaped mandibles for piercing. The genus *Styletoentomon* is erected to contain these two with *Eosentomon rostratum* as the type-species.

Styletoentomon Copeland, new genus

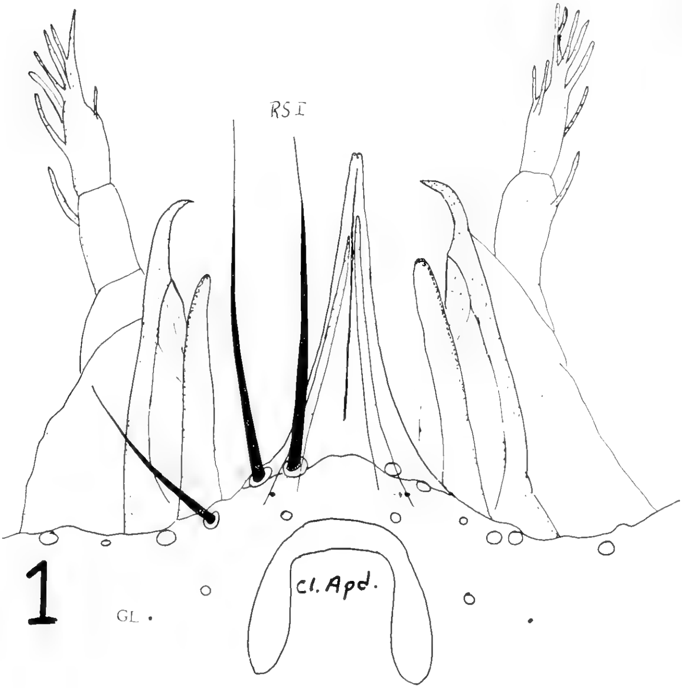
Diagnosis.—Eosentomids with spiracles and 3 pairs of 2-segmented abdominal appendages. Mandibles very long, extremely slender and sharp pointed. Labrum longer than mandibles and very narrow. Foretarsal sensilla e and g clavate. The only characters not shared by 1 or more species in the other genera are the stylet-shaped mandibles and extremely narrow labrum.

Styletoentomon rostratum (Ewing), NEW COMBINATION

Eosentomon rostratum Ewing, 1940:520.

Styletoentomon styletum Copeland, new species

This form is closely related to *Styletoentomon rostratum* (Ewing, 1940) in that they both possess long, slender, stylete-shaped mandibles and in this



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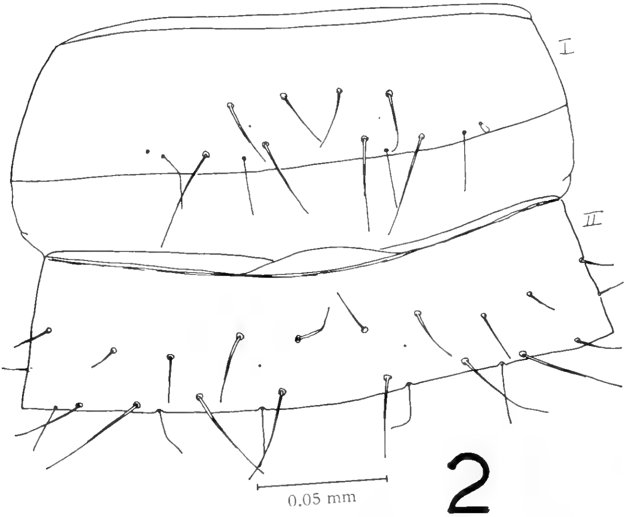

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Figs. 1–2. *Styletoentomon styletum.* 1, Labrum and mouthparts; RS I, rostral seta; GL, gland pore; Cl. Apd., clypeal apodeme. 2, Abdominal terga I–II.

respect differ from all other Eosentomidae. It differs from S. *rostratum* in the absence of foretarsal sensillum b′–1 and in smaller body size. Body length fully extended averages 1300 μ and foretarsal length 115 μ. In S. *rostratum* b′–1 is present, body length averages 1700 μ and tarsal length 125 μ.

Holotype.—♀, 1125 μ long but not fully distended.

Description.—Head: Almost round excluding labrum; capsule length 139 μ, with labrum 175 μ. Labrum (Fig. 1) extremely narrow and without labral setae. Mandibles rapier like and not flattened at base; rostral setae III ½ as long as RS-I, RS-III:I = 0.53. Lacinia I poorly sclerotized, blunt tipped and not hooked; lacinia II well sclerotized and strongly hooked. Maxillary palpi resembling those of *Eosentomon vermiforme* Ewing and S. *rostratum.* Clypeal apodemes distinct, connected anteriorly.

Thorax: Three wedge-like sensilla in each pleural membrane between thorax I-II. *Filamento de sostegno* in prothorax. Mesothoracia seta P 1 shorter than distance to its homolog (35:43) and longer than P 1′. Setae-sensilla P 3′ setiform.

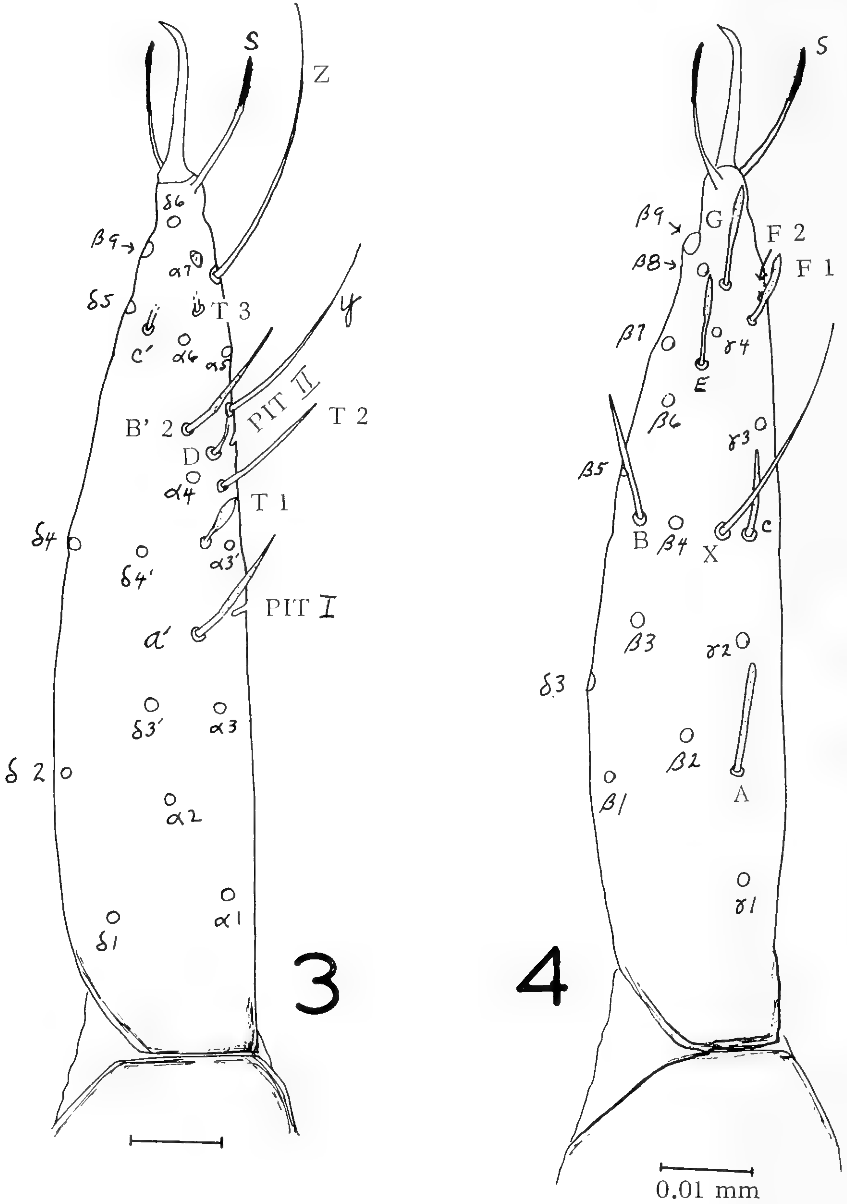
Tarsi: Foretarsus (Figs. 3–4) broader relative to length than in *E. veriforme*, length excluding claw 99 μ. Sensillum t-1 inserted on level of α 3′; t-2 setiform, long and inserted on level of α 4. Sensillum a′ setiform, shorter than distance to α 4, 15:19; b′–1 absent; b′–2 setiform, broad and long; c′ present but indistinct except for base; sensillum a extending ¾ distance to γ 2; b strong, tip at base of β 6; c long, not setiform; g clavate with small club, long shank, inserted near level of β 8. Tarsal pit 1 distinct and nearer a′ than α 3′; pit 2 nearer d than y. Ratios: BS 1.44; TR 5.7; EU 0.90.

Tarsus III bearing the usual strong, dorsal, subapical spine; empodium very short. Claws II-III with very fine tooth on upper surface.

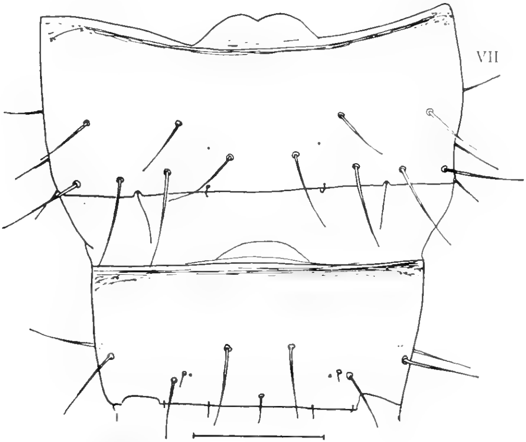
Abdomen: Posterior row of setae on tergum I (Fig. 2) with 2 primary, 2 accessory and 1 microchaeta on each side. Primary setae longer than corresponding accessories, 34:20. Seta P 1′ on t VII (Fig. 5) very short, peg-like, without terminal “brush” and inserted on posterior margin of tergum. Sternum VIII with 2 anterior and 7 posterior setae, the P 2 almost in line with P 1-P 3; sterna IX-X with 4 setae each. Abdominal chaetotaxy shown in Table 1.

Genitalia: Female squama genitalis (Fig. 6) similar to that of S. *rostratum* and *E. veriforme.* The processus sternales sharp-pointed and evenly bent giving a stoop-shouldered appearance. No unusual features noted in male apparatus.

Discussion.—The most characteristic features of this species are the very long narrow labrum, stylete-shaped mandibles, prominent clypeal apodemes, the 2:2:1 seta ratio on tergum I and the absence of tarsal sensillum b′–1. The positions, shapes and sizes of the tarsal sensilla conformed closely to



Figs. 3–4. *Styletoentomon styletum.* 3, Foretarsus, dorsal view. 4, Foretarsus, ventral view.



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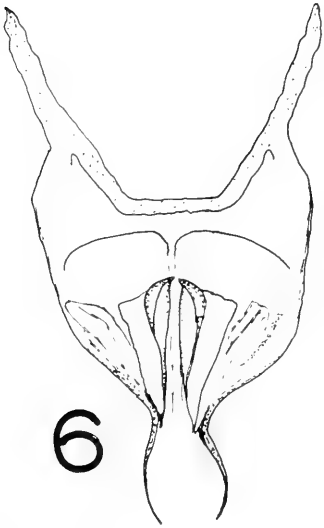

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Figs. 5–6. *Styletoentomon styletum.* 5, Abdominal terga VII–VIII. 6, Female genital apparatus.

Table 1. Abdominal chaetotaxy for *Styletoentomon styletum.*

Abdomen	I	II–III	IV	V–VI	VII	VIII	IX–X	XI	XII
Tergum	4/10[a]	10/16	10/16	8/16	6/16	6/9	8/—	8/—	9/—
Sternum	4/4	6/4	6/10	6/10	6/10	2/7	4/—	8/—	12/—

[a] Two primary, two accessory, and one microchaeta on each side.

those on the type as did the numbers, positions and shapes of the abdominal setae, specifically the P 1′ of t VII, the P 1″ and P 2 on t VIII, the P 1–2–3 on that sternum and the 4–4 seta number on s IX-X.

The species is known from approximately 175 specimens taken at altitudes of less than 775 m in Tennessee, Arkansas, North and South Carolina and Virginia. Samples from elevations over 775 m yielded over 400 examples of the closely related form S. *rostratum* but only 10 of S. *styletum.*

Holotype and type-locality.—The holotype ♀, on slide TN 283-1 taken by T. P. Copeland from deciduous leaf litter 8 miles east of Speedwell (Claiborne Co.), TN., 21 July 1953.

Material examined.—The species is known from the holotype and paratypes from the following localities; collector, T. P. Copeland unless indicated otherwise: Speedwell, Claiborne Co., TN., 21 July 1953. Sex and slide numbers: ♀, 280-1: ♂, 281-2; 292-1: Imm., 293-1. Anderson Co., TN., 21 July 53. ♀, 287-3: Imm., 286-3. Campbell Co., TN., 21 July 53. ♀, 292-1: ♂, 293-3: Imm., 293-1. Blount Co., TN., 1 July 53. ♀♀, 98X-1; 99-1; 99-3; 99-4; 99-5; 99-6; 99-8: ♂ 99X-1. Smoky Mt. Nat. Park, Cades Cove, Blount Co., TN., 1 July 53. ♀♀, 101-15; 101-17: Imm., 101-8. Sevier Co., Dupont Mt., TN., 20 Apr. 52. ♀♀, 21-25; 21-26; ♂, 21-3; 21-28. Sequatchie Co., TN., 30 July 53. ♀, 395-1. Hamblen Co., TN., 26 July 53. Imm., 296-2 (2). Jefferson Co., TN., 20 June 59. Imm., 270-2. Lenoir City, TN., 8 Oct. 59. ♂, 520-1. Cedars of Lebanon State Park, TN., 12 Oct. 62. ♀♀, 723E-3; 723E-5; 723E-12; 724G-5, 724-4; 724-11; 724G-12: ♂♂, 723-3; 723E-7; 723E-11; 723E-15: Imm., 724-13. Shelby Forest State Park, TN., Coll. J. S. Henderson, summer, 1969. ♀, 110-1: ♂♂, 111-4; 111-5; 124-13. Chickasaw State Park, TN., Coll. G. Hunnicutt, 26 June 64. ♀♀, 25-7; 27-10; 27-13; 28-3, 30-1; 30-2, 30-4; 96-16; 109-8: ♂♂, 16-2; 27-11; 27-18; 28-6; 30-9; 30-11. Natches Trace State Park, TN., Coll. T. D. Diamond, 26 June 64. ♀♀, 1-1; 1-6; 3-6; 30-4; 40-2; 41-2; 42-1; 42-6; 42-7; 44-3; 44-4; 46-1; 48-2; 50-12; 74-1; 74-3; 74-4; 74-7; 75-1; 75-2; 75-3; 76-2; 76-3; 76-9; 76-11; 76-15; 79-3; 88-3; 98-1; 98-2; 98-6; 98-7; 98-9: ♂♂, 1-7; 3-9; 48-6; 50-14; 74-5; 75-3; 98-8; 76-5; 76-10; 98-3. Reelfoot Lake, TN., Coll. R. Davis. Aug. 63. ♀♀, 4-3; 4-9; 4-11; 4-12; 4-13; 4-20; 4-22; 4-24: ♂♂, 4-5; 4-7; 4-8; 4-18; 4-21; 4-23; 9-7. Highlands, No. Car., Coll. T. Copeland, 25 June 77. ♀♀, 880-1; 880-4; 881-1: ♂ 880-2: Imm., 880-7; 880-9; 880-10; 880-12; 880-14.

Deposition of type-material.—The holotype and a male paratype will be deposited in the National Museum of Natural History, Smithsonian Institution. Male and female paratypes will be given to Dr. S. L. Tuxen, Zoological Museum, Copenhagen, Denmark and to Dr. Gentaro Imadaté, Tokyo Medical and Dental University, Tokyo, Japan. The remainder will be retained by the author.

Eosentomon erwini Copeland, new species

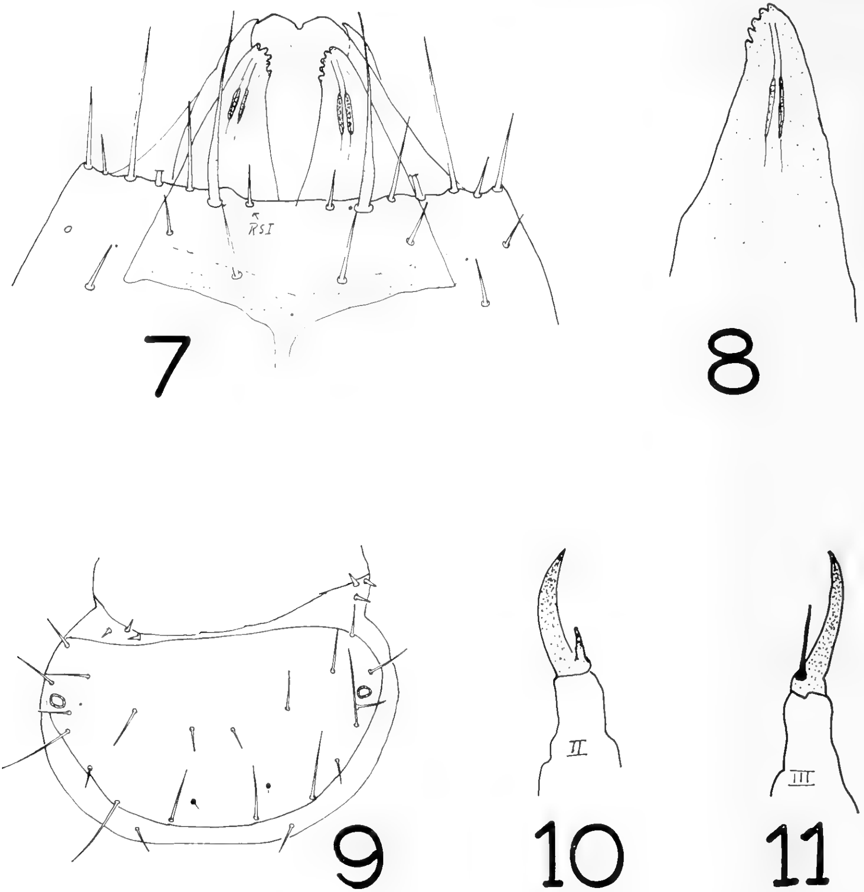
This species belongs to the *wheeleri* (2/7) group of Bonet and Tuxen (1960) and to the 3:1:1 sub-group. Its closest relatives are most likely members of the latter group and in the United States only *Eosentomon wheeleri* Silvestri, *Eosentomon pseudowheeleri* Copeland, *Eosentomon tennesseense* Copeland, *Eosentomon pusillum* Ewing, *Eosentomon quadridentatum* Copeland, *Eosentomon yosemitense* Ewing and possibly *Eosentomon christianseni* Bonet possess the requisite features.

This form can be easily differentiated from all other U.S. *Eosentomon* species by the massive size of the mouthparts, especially the mandibles. In having a long empodium on tarsus III, it resembles *Eosentomon pallidum* Ewing and *E. pusillum* but differs from those species in that *E. pallidum* has no anterior setae on sternum VIII, six setae each on sterna IX-X and t-1 inserted nearer α 3 than to α 3′. In *E. erwini* sternum VIII has two anterior setae, four setae each on sterna IX-X and sensillum t-1 inserted near level of α 3′. In *E. pusillum* the clypeal apodemes are very conspicuous, mouthparts including labrum very short, t-1 placed nearer seta α 3, body length 570 microns and foretarsus without claw 55 microns. In *E. erwini* clypeal apodemes indistinct or absent, with huge mouthparts, t-1 nearer α 3′ than to α 3, body length 1500 μ and tarsal length 100 μ.

Holotype.—♀, on slide TN. 727-23, 1515 μ in length and narrow body giving a long slender appearance.

Description.—Head: Egg shaped, capsule excluding rostrum 115 μ. Labrum (Fig. 7) very wide at base and long, length 32 μ, terminating in a broad V-shaped apical notch with a wide, shallow, median cleft; LR 3.65. Pseudoculus divided and much broader than long, 15:9. Labral setae absent. Rostral setae I extremely short, 7 μ, not flattened and only ½ as long as RS III. Rostral setae II longer than labrum and flattened (winged) in basal ⅓. Mandibles (Figs. 7–8) very large and massive, terminating in 5 prominent teeth. Clypeal apodemes either absent or obscured.

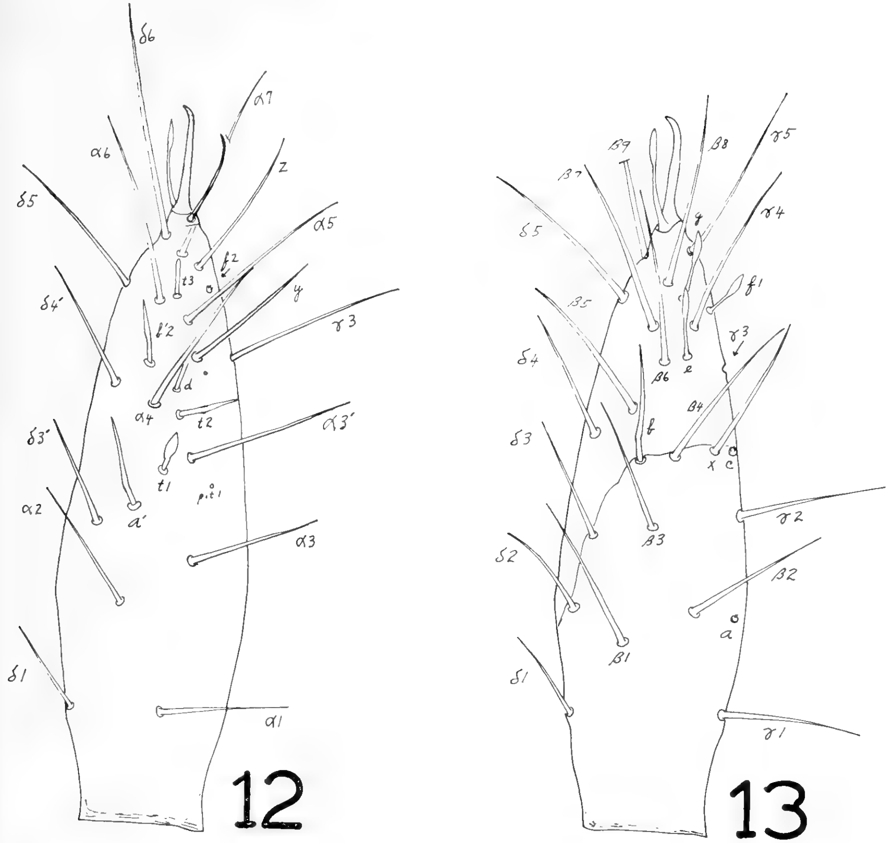
Thorax: Three prominent wedge-shaped sensilla (Fig. 9) in each pleural



Figs. 7–11. *Eosentomon erwini.* 7, Labrum and mouthparts; RS I, rostral seta. 8, Mandible. 9, Mesothoracic tergum. 10, Tarsus II claw and empodium. 11, Tarsus III claw and empodium.

membrane between thorax I-II. Glands of *filamento de sostegno* in mesothorax: Seta P 1 on that tergum far shorter than distance to its homolog (27:35) but longer than P 1′ (27:14). Tergal setae P 3′ on thorax II-III long for these setae; another sensillum immediately adjacent to seta A 4 on metathorax plus 1 further removed from that seta.

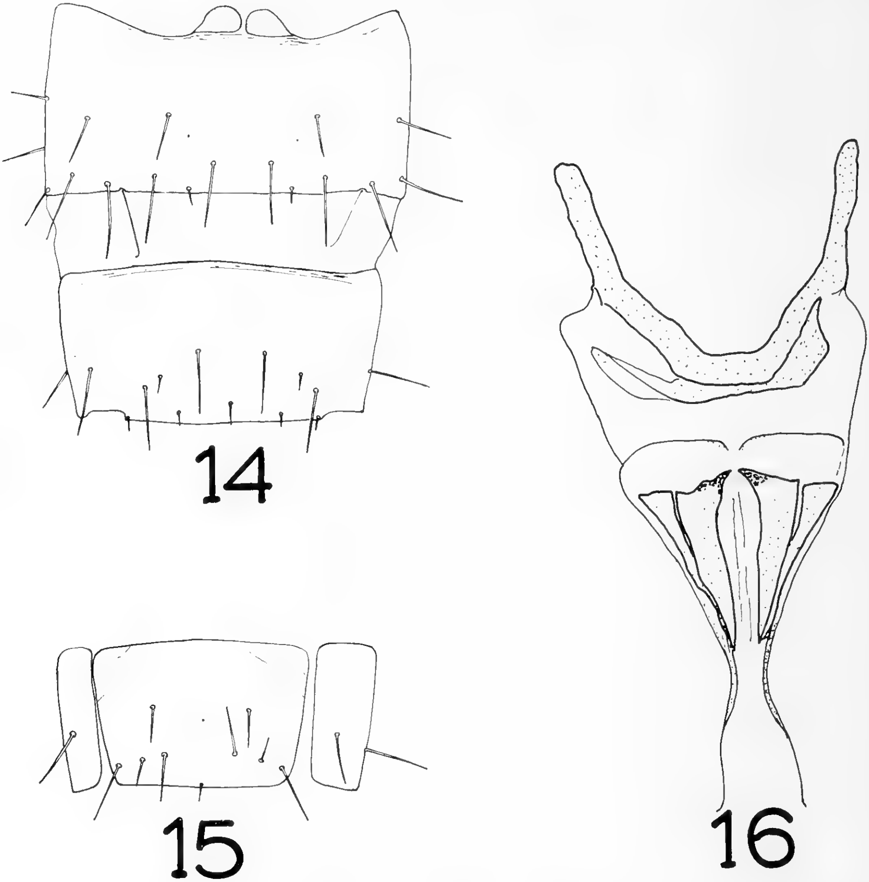
Tarsi: Foretarsus (Figs. 12–13) relatively broad, length 103 μ. The t-1 inserted slightly proximal to level of α 3′; t-2 narrow lanceolate and inserted on level of α 4; t-3 extending to base of α 7; a′ setiform, tip reaching base of α 4; b′-1 absent; b′-2 lanceolate, equal length to t-2 but slightly



Figs. 12–13. *Eosentomon erwini.* 12, Foretarsus, dorsal view. 13, Foretarsus, ventral view.

broader; c′ very short; sensillum a indistinct except for base but in paratypes length varied from ½ to ⅔ distance to γ 2; b setiform and extending to midpoint between β 6 and β 7; c indistinct except for socket but in paratypes varied from ½ to ⅔ distance to γ 3; e and g clavate with long shanks and small clubs; f-1 clavate, club approximately equal in size to those of e and g. Tarsal pits 1 and 2 prominent. Shapes, sizes and locations of all setae and sensilla as represented in the figures. Tarsus II empodium (Fig. 10) ⅕ length of claw; tarsus III empodium (Fig. 11) longer, ⅔ length of claw; claws not toothed.

Abdomen: Abdominal tergum I with 3 primary, 1 accessory and 1 microchaeta on each side in posterior row. Abdominal accessory setae longer than corresponding primaries, t IV P 1-P 1′ 23:28. On t VII P 1′



Figs. 14–16. *Eosentomon erwini.* 14, Abdominal terga VII–VIII. 15, Abdominal sternum VIII. 16, Female genital apparatus.

(Fig. 14) very short setiform, not at all filamentous, inserted along the posterior margin of the tergum and not "brush" tipped. On t VIII the P 1″ peg-like with long terminal filament. Sternum VIII (Fig. 15) with 2 anterior and 7 posterior setae, P 2 almost in line with P 1-P 3. Sterna IX-X with 4 setae each. Abdominal chaetotaxy represented in Table 2. Unfortunately, the type has a setal abnormality in anterior row of tergum VI, 3 on 1 side instead of 4. Paratypes have 4 on this segment.

Genitalia: The female apparatus (Fig. 16) characterized by prominent basal apodeme possessing a long plate at base; processus sternales with very sharp pointed, dense tips; posterior valves and filaments long.

Discussion.—The species is known from 61 females, 13 males and 20

Table 2. Schematic representation of abdominal chaetotaxy for *Eosentomon erwini.*

Abdomen		I	II–III	IV	V–VI	VII	VIII	IX–X	XI	XII
Tergum	a	4	10	10	8	6	6	8	8	9
	p	10[a]	16	16	16	16	9			
Sternum	a	4	6	6	6	6	2	4	8	12
	p	4	4	10	10	10	7			

Abbreviations: a = anterior row; p = posterior row.

[a] Three primary, one accessory and one microchaeta on each side.

immatures, an unusual ratio of females to males. There is little variation among the individuals for all characters studied. The most characteristic features are: Size and shape of labrum, massive appearance of mandibles, each with five prominent teeth; and extremely short rostral setae I giving RS III:I ratio of 2.0 and winged condition of rostral setae II. The arrangement of setae P 1-2-3 on sternum VIII is uniform in all specimens. The pseudoculi are never prominent and often difficult to find. Clypeal apodemes are either absent or obscured. Sizes, shapes and locations of all sensilla conformed closely to those on the type. Three sensilla are present in pleural membranes between thorax 1-2 on all specimens. On the foretarsus, sensillum c′, when it could be clearly seen, is very short, little more than nipple-like in appearance; b′-1 is always absent; sensillum s has a very small or no club; the f-1 is always clavate, and tarsal pits 1 and 2 are prominent and uniform in location. There was no variation in the 3:1:1 seta ratio on abdomen I and in the relative lengths of primary to accessory setae, the latter being longer. On sternum VIII the P 2 is always nearly in line with P 1-P 3. In other species this is not always so but it is consistent for each species. Four adult individuals had variations in abdominal setae number but these involved only the loss of a single seta on one side. The female genital apparatus is consistently uniform in appearance except for minor distortions apparently caused by pressure from the cover glasses.

Type-locality.—Near Tennessee, State Fish Hatchery, Erwin, Tennessee. All specimens taken in leaf litter from black cherry trees and honeysuckle vines.

Types and deposition.—The holotype, ♀, on slide TN 727-23 and 93 paratypes all with numbers TN 727, collected by T. P. Copeland, 23 May 77. The type will be temporarily retained in East Tennessee State University museum but eventually it and a male will be deposited in the National Museum of Natural History, Smithsonian Institution. A paratype male and female will be deposited with Dr. S. L. Tuxen, Zoological Museum, Copenhagen, Denmark and Dr. Gentaro Imadaté, Tokyo Medical and Dental University. All others will be retained by the author.

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Department of Biology, East Tennessee State University, Johnson City, Tennessee 37601.

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80(4), 1978, pp. 485–492

A NEW SPECIES OF *EOSENTOMON* (PROTURA: EOSENTOMIDAE) FROM NORTH CAROLINA AND TENNESSEE

T. P. Copeland and Charlie White

Abstract.—*Eosentomon pseudoyosemitense* White, new species, is described. Its distribution in Tennessee–North Carolina and a table summarizing differences among 10 species of U.S. *Eosentomon* are given.

Eosentomon pseudoyosemitense White, new species

White using material that had been collected by Copeland in 1959–1961 originally described this species in his M.S. thesis (1966) but this has not been published. In 1977 Copeland made additional collections in the vicinity of Highlands, North Carolina and the following description and drawings were made by him from a specimen taken near Bridal Veil Falls.

In most characters but especially in the shape of the female genital apparatus *E. pseudoyosemitense* is closely related to *Eosentomon yosemitense* Ewing (1940), both have the processus sternales in the form of two semicircles. However, *E. yosemitense* has no anterior setae on sternum VIII while *E. pseudoyosemitense* possesses two. These and other differences in related species are summarized in Table 1, some of the information taken from Bonet and Tuxen (1960).

Holotype.—♀, 725 μ long but not fully distended and poorly sclerotized.

Description.—Head: Egg shaped, length excluding labrum 89 μ. Labrum length 6 μ; terminating in a flat V-shaped notch with relatively broad, deep, median cleft (Fig. 1); LR 14.8. Labral setae present. Rostral setae I much broadened in basal ½ and equal length to III. Pseudoculi large, 11 μ; PR 8.0, PR derived by dividing the pseudoculus length into head capsule length. Mandibles partially obscured but in paratypes terminate in 3 teeth. Lacinia II hooked but not as strongly as in *Eosentomon vermiforme* Ewing. Clypeal apodemes connected anteriorly.

Thorax: Glands of *filamento de sostegno* in mesothorax (Fig. 4). Spiracular setae P 3′ setiform and relatively long for these setae. Two sensilla located in each membranous pleural area between thorax I–II and 1 immediately adjacent to setae A 4 on metathoracic tergum. Mesothoracic seta P 1 length ½ as long as distance to its homolog and slightly longer than p 1′.

Tarsi: Foretarsus (Figs. 2–3) short and broad, length 65 μ; BS 0.77. Sensilla t-1, e, g and s with huge clubs. The t-1 inserted very near to α 3; e between β 6 and γ 4; g closer to β 8 than γ 4. Sensillum b narrow

Table 1. Summary of similarities and differences among selected species of U.S. *Eosentomon*.

	A	B	C	D	E
Labrum length	6.8	31	13	19	14
Labral setae present	+	0	+	+	+
Ros. setae III:I	1.0	0.3	1.0	0.5	1.0
Foretarsus length	69	125	89	103	113
BS ratio	0.80	1.45	1.40	1.35	1.51
Sensillum b′ 1 pres.	+	0	0	0	0
t-1 closer to α 3′ than α 3	0	+	+	+	+
Seta no. ant. row t IV	8	10	10	10	8
Seta no. ant. row t V–VI	8	8	8	8	8
Abd. acc. setae longer	+	0	+	0	+
Setae no. s VIII	2/7	2/7	2/7	2/7	2/7
Setae no. s IX–X	6	6	6	4	4

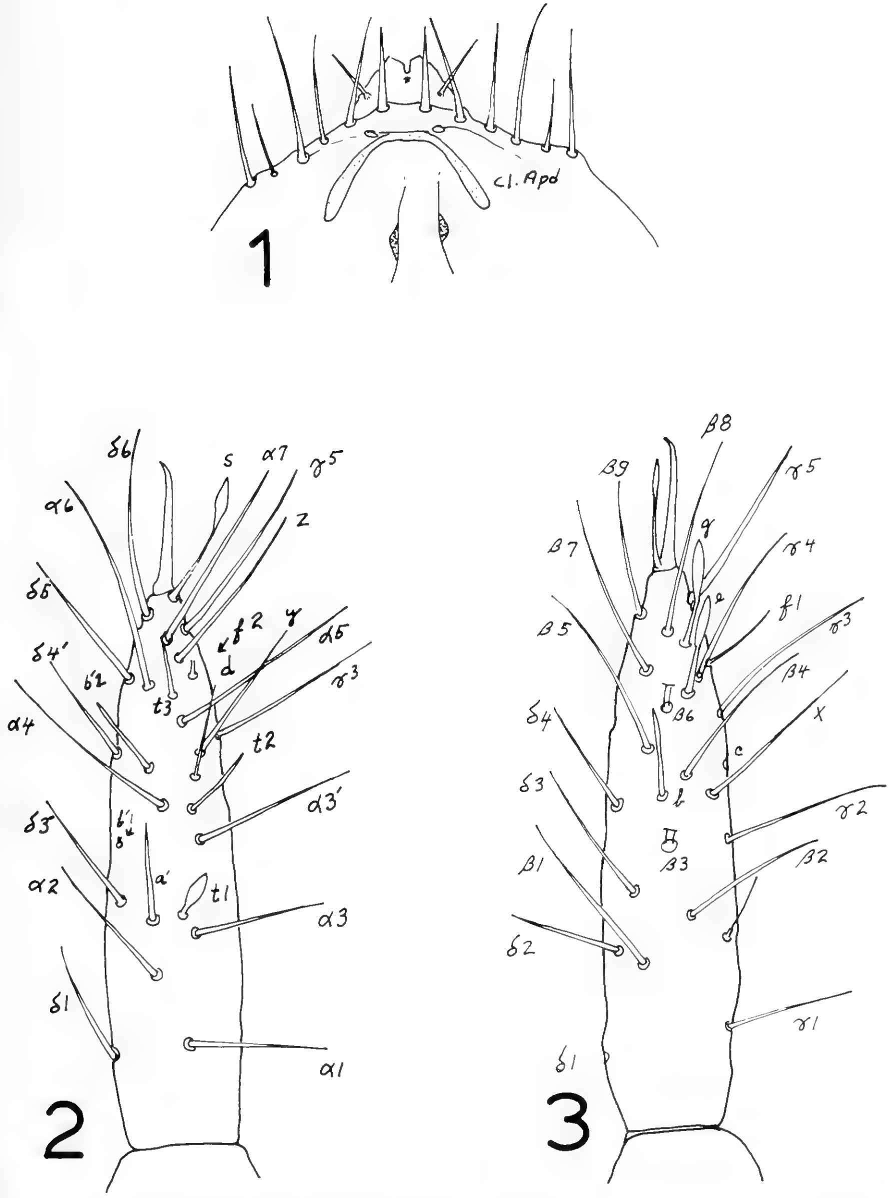
	F	G	H	I	J
Labrum length	?	?	15	15	32
Labral setae present	+	?	+	+	0
Ros. setae III:I	?	?	0.8	0.7	2.0
Foretarsus length	?	80	113	108	103
BS ratio	0.81	0.90	0.98	0.84	1.42
Sensillum b′ 1 pres.	0	?	+	+	0
t-1 closer to α 3′ than α 3	0	0	0	0	+
Seta no. ant. row t IV	10	8	10	10	10
Seta no. ant. row t V–VI	10	6	8	8	8
Abd. acc. setae longer	+	+	0	0	+
Setae no. s VIII	2/7	0/7	0/7	0/7	2/7
Setae no. s IX–X	6	4	6	6	4

A. *E. pseudoyosemitense*
B. *E. quadridentatum*
C. *E. wheeleri*
D. *E. pseudowheeleri*
E. *E. tennesseense*
F. *E. pusillum*
G. *E. yosemitense*
H. *E. dureyi*
I. *E. pallidum*
J. *E. erwini*

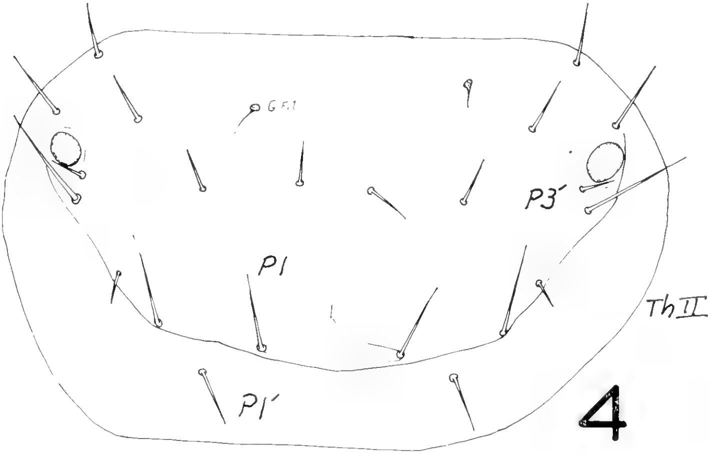
lanceolate, tip barely reaching base of β 6; f-1 setaceous; a′ narrow lanceolate, inserted near the level of t-1; pits 1 & 2 extremely small, represented only as tiny white spots, the former near α 3′ and the latter very close to and on level of y. Sensillum b′-1 present; c′ absent. Shapes, sizes and locations of all sensilla as figured.

Tarsus III with the usual strong dorsal spine; claw not toothed; empodium very short.

Abdomen: Posterior row on tergum I with 3 primary, 1 accessory and 1 microchaeta (3:1:1) on each side. Abdominal accessory setae longer than corresponding primaries, t IV P 1:P 1′ = 15:18. On t VII (Fig. 5)



Figs. 1–3. *Eosentomon pseudoyosemitense*, holotype. 1, Labrum; Cl. Apd., clypeal apodeme. 2, Foretarsus, dorsal view. 3, Foretarsus, ventral view.



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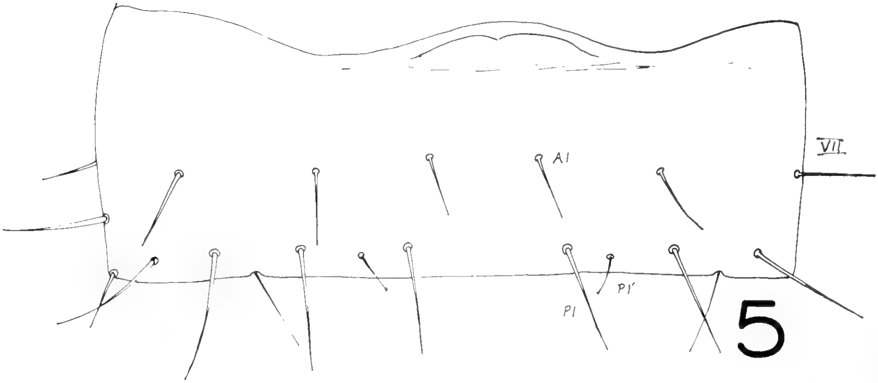

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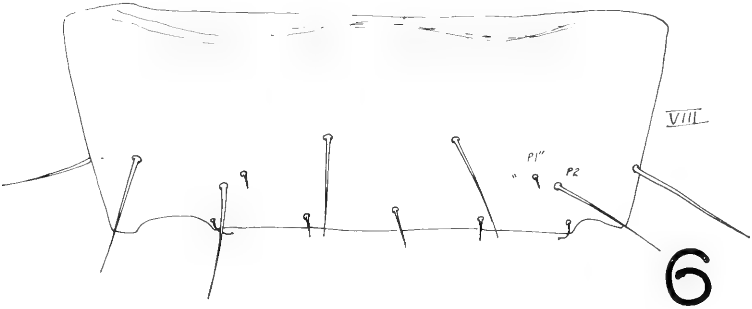

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seta P 1 not displaced anteriorly; P 1′ filamentous, relatively long for this seta, terminating in a "brush" tip and inserted near level of P 1–P 2. Arrangements of setae on t VIII as in Fig. 6. Sternum VIII (Fig. 7) with 2 anterior and 7 posterior setae, the P 2 not greatly displaced anteriorly. Sterna IX–X with 6 setae each. Abdominal chaetotaxy shown in Table 2.

Genitalia: The processus sternales of the female apparatus (Fig. 8) roughly in shape of 2 semicircles. Laterally just posterior to the basal apodeme arms a thin dark line present and internally from each, 2 more or less oval structures present.

Discussion.—The species is known from Highlands and Mount Mitchell, North Carolina and Roan Mountain, Smoky Mountain National Park, Chickasaw State Park and Newport, Cocke County, Tennessee. All specimens except those from Newport, were collected at or above 1100 m elevation. Repeated collecting at the Newport site failed to produce additional specimens. Total number of adults collected were 52, plus immatures which were not examined.

There are no variations in the possession of labral setae, only two sensilla in each pleural area between thorax I–II, the 3:1:1 tergum I seta ratio, two anterior and seven posterior setae on sternum VIII and six setae on each sterna IX–X. One individual had an extra seta on one abdominal tergum, and one specimen had one less. On tergum VII the positions of setae P 1 were constant as were the shapes and positions of the P 1′. On tergum VIII the positions of the P 2 and P 1″ were relatively constant as were the positions of the setae on that sternum, specifically the setae P 2.

The labrum always terminated in a flat V-shaped notch with a broad, deep, median cleft; LR ranged from 11.4 to 16.6 with a median of 14.6. The PR ranged from 7.4 to 10.6, median 9.3.

The foretarsal sensilla shapes, sizes and locations were as on the holotype with most characteristic features being the huge clubs on sensilla t-1, e, g and s, the t-1 always inserted very close to seta α 3 and c′ absent on all specimens. The BS ranged from 0.69 to 0.86, median 0.76.

Location of the glands of the *filamento de sostegno* varied from most posterior portion of prothorax to anterior half of the mesothorax, more often found in the latter. It is felt that they lie within the mesothorax near its anterior border unless displaced by pressure from the cover glass.

Some variation existed in the appearance of the female apparatus but

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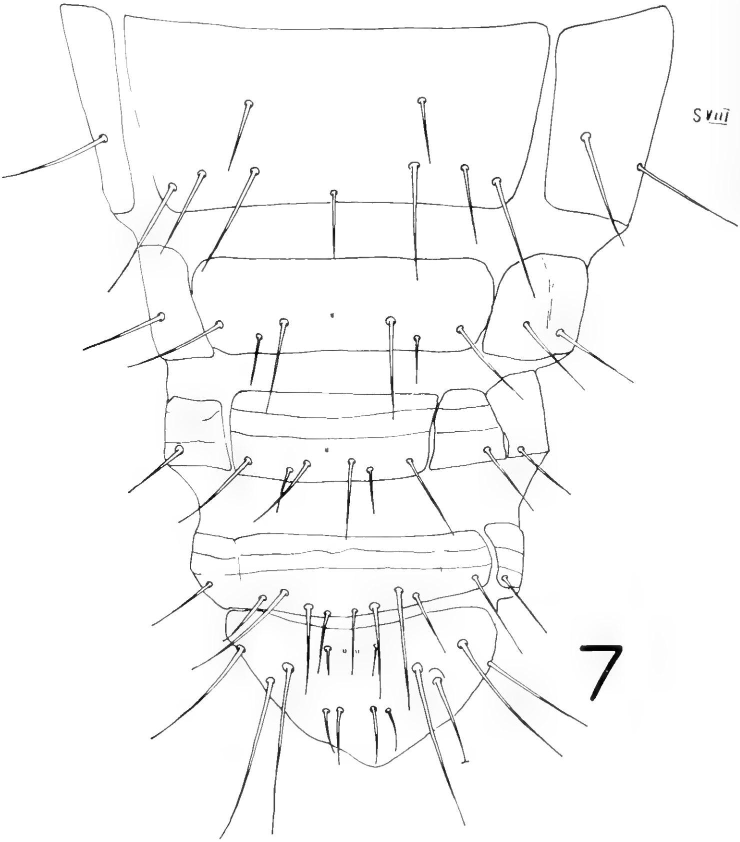
Figs. 4–6. *Eosentomon pseudoyosemitense*, holotype. 4, Mesothorax; G. Fil., glands *filamento de sostegno*, P 1, P 1′, P 3′ setae. 5, Abdominal tergum VII. 6, Abdominal tergum VIII.



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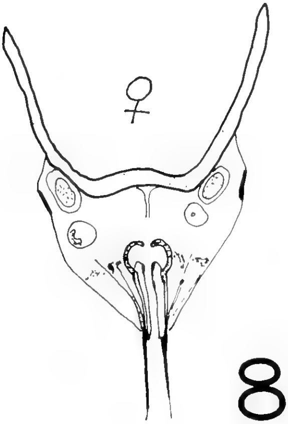

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Table 2. Schematic representation of abdominal chaetotaxy for *Eosentomon pseudoyosemitense.*

Abdomen		I	II–III	IV–VII	VIII	IX–X	XI	XII
Terga	a	4	8	8	6	8	8	9
	p	10[a]	16	16	9			
Sterna	a	4	6	6	2	6	8	12
	p	4	4	10	7			

Abbreviations: a = anterior row; p = posterior row.

[a] Three primary, one accessory and one microchaeta on each side.

it is felt this is more apparent than real, probably distortions caused by pressure of the cover glasses. The four oval spots shown in the genital apparatus appear to be of no taxanomic significance as they are often not present in female paratypes. No unusual features in the male apparatus observed. A North Carolina specimen was selected for the holotype because White's original specimen is in poor condition.

Type-locality.—Bridal Veil Falls on Highway 64, two miles west of Highlands, North Carolina.

Types and deposition.—The holotype, a female on slide NC 881-13 collected 25 June 1977 by T. P. Copeland from deciduous leaf litter, 3600 ft., Bridal Veil Falls, Natahala National Forest, approximately 2 miles west of Highlands, North Carolina.

Paratypes: The species is also known from 51 paratypes, 32 ♀ and 19 ♂. Paratypes from the following localities: Highlands, North Carolina, Coll. T. Copeland, 25 June 1977, deciduous leaf litter, 3600–3800 ft., slide nos.; ♀♀, X-5; 886-1; 887-10; 888-21; 888-45; 888-49; 888-58; 889-8; 889-32; 889-39; 890-F-Z; 890-I-1; 890-S-2; 891-F-1; ♂♂, 879-8; 881-22; 881-31; 885-3; 887-12; 888-67; 889-1A; 890-0-3; 891B-23. Mt. Mitchell, North Carolina, Summer 1962, Coll. R. A. Durey, 4500–6500 ft., slide nos.; ♀♀ 45-12/1; 48-8/5; 60-4/7; 65-8/2; 65-15/1; 65-15/2; 65-15/3; 65-15/7; 65-15/8. Smoky Mt. Nat. Park, Sevier Co., Tenn., 4000 ft., Hwy 441, Coll. T. Copeland, 27 Oct. 59, slide nos: ♀♀, 621-8; 622-8; 622-9: Trout Branch, S.M.N. Park, 27 Sept. 61, 712-X8-2; 712-X8-5; 712-X20-2; ♂♂, 712-X8-2; 712-X8-5; 712-X20-2; 712-X8-3. Newport, Tenn. Coll. T. Copeland, 23 Nov. 61; ♂♂, 717-3; 718-11. Roan Mountain, Tenn., Coll. T. Copeland, 11 Oct. 59; ♂ 558-3. Chickasaw State Park, Tenn., Coll. G. Hunnicutt, 26 June 1964, slides GSH; ♀♀, 55-5; 97-5; 132-17; ♂♂, 117-30; 120-3; 122-28.

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Figs. 7–8. *Eosentomon pseudoyosemitense*, holotype. 7, Sterna VIII–XII. 8, Female genital apparatus.

The holotype and a male paratype will be deposited in the National Museum of Natural History, Smithsonian Institution. Male and female paratypes will be given to Dr. S. L. Tuxen, Zoological Museum, Copenhagen, Denmark and to Dr. Gentaro Imadate, Tokyo Medical and Dental University, Tokyo, Japan. All others will be retained in the East Tennessee State University Museum.

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(TPC) Department of Biology, East Tennessee State University, Johnson City, Tennessee 37601; and (CW) Department of Biology, New River Community College, Dublin, Virginia 24084.

PROC. ENTOMOL. SOC. WASH.
80(4), 1978, pp. 493–507

STUDIES ON THE GENUS *FORCIPOMYIA*. V. KEY TO SUBGENERA AND DESCRIPTION OF A NEW SUBGENUS RELATED TO *EUPROJOANNISIA* BRÈTHES (DIPTERA: CERATOPOGONIDAE)

Willis W. Wirth and Niphan Chanthawanich Ratanaworabhan

Abstract.—*Saliohelea,* new subgenus of the genus *Forcipomyia* Meigen, is proposed for *F. leei,* new species (type-species), from the Nearctic and Neotropical regions, *F. brevicosta* (Clastrier) from West Africa, *F. deminuta* Tokunaga and Murachi from the western Pacific, and *F. stami,* new species, from Zaire. A provisional key to the subgenera of *Forcipomyia* is presented. *Saliohelea* is most closely related to *Euprojoannisia* Brèthes and differs mainly in the complete fusion of the fourth and fifth palpal segments, the absence of mandibular teeth in the female, the characteristically sclerotized margins of the male aedeagus and the shape and arrangement of the spiracular openings on the pupal respiratory horn. It is also related to *Warmkea* Saunders, from which it differs in its shorter costa and distal antennal segments, the shape of the fourth palpal segment, the absence of mandibular teeth in the female and the arrangement of the spiracular openings on the pupal respiratory horn.

We have become especially interested in the classification of the small, inconspicuously brownish, hairy, biting midges of the genus *Forcipomyia* Meigen because of their importance in the pollination of cacao (*Theobroma cacao* L.) and other tropical crop plants (Saunders, 1956 and 1959; Dessart, 1961 and 1963; Barroga, 1964; Soria and Wirth, 1974; Kaufmann, 1975; Winder, 1977). There is a small group of species for which we have found characters of the female, male and pupa that in our opinion, justify the description of a new subgenus.

The modern classification of the genus *Forcipomyia* is well grounded in the recent works of Saunders (1956 and 1959), Tokunaga and Murachi (1959), Dessart (1963), and Chan and LeRoux (1965 and 1971). Readers are referred to these authors for explanation of our terminology and a fuller discussion of subgeneric classification.

We are especially indebted to Paul G. Bystrak, Maryland Department of Agriculture, Annapolis, for his excellent research on the taxonomy of all stages of the North American species of the subgenus *Euprojoannisia* Brèthes. His work has given us a much deeper insight into the taxonomy of this subgenus as well as those others most closely related to the new subgenus. Mr. Bystrak provisionally included our new species *F. leei* in his unpublished thesis (Bystrak, 1974) and has permitted us to draw freely upon his description and discussion.

Tokunaga and Murachi (1959) gave a short diagnosis of what they termed "Subgenus C" for a provisional group containing only the species *Forcipomyia deminuta* Tokunaga and Murachi from Micronesia. They compared "Subgenus C" with the subgenera *Proforcipomyia* Saunders and *Synthyridomyia* Saunders. Dessart (1963) commented on Tokunaga and Murachi's "Subgenus C" and included it in his keys to the African subgenera of *Forcipomyia*; he assigned the African species *Lasiohelea brevicosta* Clastrier to this subgenus. We have found two additional undescribed species that fit in this group and with sufficiently distinct characters of the adult and pupa to prompt us to described a new subgenus to contain them.

Forcipomyia, subgenus *Saliohelea* Wirth and Ratanaworabhan, new subgenus

Fig. 1

Forcipomyia, subgenus C; Tokunaga and Murachi, 1959:219, Dessart, 1963:24.

Type-species.—*Forcipomyia* (*Saliohelea*) *leei* Wirth and Ratanaworabhan, new species.

Description.—Small, unmarked, yellowish to brownish species. Female antenna (Fig. 1b) with five distal segments not much longer than preceding segments, AR 0.78–1.20. Palpus (Fig. 1a) 4-segmented, primitive 4th and 5th segments fused without trace of articulation, characteristically tapering to slender tip; 3rd segment with or without sensory pit. Mandible teeth absent.

Body, wings and legs usually more or less clothed with elongate, slender, scalelike hairs with 1–3 stripes or striations. Costa (Fig. 1d) short, costal ratio 0.41 to 0.52 in female. Hind tibial comb (Fig. 1h) with 4–5 slender spines in distal series. Hind tarsal ratio varying from 1.7 to 2.7; hind basitarsus of male sometimes expanded dorsally. Empodium (Figs. 1g and 1j) well developed in both sexes; claws rather slender and curved.

Female with a single well-developed spermatheca (Fig. 1i), this usually tapering to slender neck, a minute rudimentary 2nd spermatheca usually present. Male genitalia (Figs. 1m and 1n) similar to those of *Euprojoannisia* or *Warmkea* Saunders. Ninth sternum more or less transverse distally, with long, slender, anterolateral projections; 9th tergum short and tapering to moderately separated, setose, apicolateral lobes. Basistyle moderately stout; dististyle long and slender, nearly straight, tapering to tip. Aedeagus somewhat variable in form, usually with triangular basal portion without well-developed basal arch or lateral arms, this portion usually with distinct marginal sclerotization; slender distal median process usually present, rounded or peglike, in 1 species with a submedian pair of slender posterior processes. Parameres with basistylar apodemes forming a more or less V-shaped basal arch, with a distinct mesal connective which is usually platelike but may be narrow; a pair of submedian posterior sclerotized processes may be present (completely absent in 2 species, short and pointed in 1 species, long and curved in 1 species).

Pupa with slender respiratory horn (Fig. 1e) bearing 6 spiracular openings spaced loosely around the apical margin giving it a crinite appearance.

Etymology.—The name *Saliohelea* is an anagram of *Lasiohelea* Kieffer, another subgenus of *Forcipomyia.*

Discussion.—Species of *Saliohelea* are most closely related to the subgenus *Euprojoannisia* (synonyms *Proforcipomyia* and *Euforcipomyia* Malloch), which they resemble in their small, unmarked, yellowish-brown appearance; tarsal ratio greater than 1.0; curved, slender tarsal claws, rather short distal antennal segments; and reduction of the last two palpal segments. Species of *Euprojoannisia*, however, differ in having palpal segments four and five both present, although their articulation is lost and they are partially fused; mandibular teeth are usually present in the female; striated scales are lacking on the body; two spermathecae are usually present; the mesal connective of the male basistylar apodemes is usually slender and rarely are indistinct posterior processes present; and the pupal respiratory horn is usually short and swollen with the spiracles arranged in a tight circle or partial circle at the apex.

The subgenus *Warmkea* is also close to *Saliohelea.* The resemblance is especially close in the complete loss of the fifth palpal segment, the presence of only one spermatheca, the general features of the male parameres, and the shape of the pupal respiratory horn. However, in *Warmkea* the distal antennal segments are usually much elongated, female mandibular teeth are present, the costa is much longer, the male aedeagus has a distinct shieldlike shape with a well-developed basal arch and no lateral thickenings, and the spiracles are arranged in a tight row on the pupal respiratory horn.

Biological information is available only for *Forcipomyia* (*Saliohelea*) *leei*, new species. Saunders reared the species from a pupa taken under bark of a fallen tree in the forest in Brazil, and Williams reared it from rotting pods of cacao in Trinidad. Numerous collections of *F. leei* were made in rain forest locations.

The following provisional key to the subgenera of *Forcipomyia* is presented for the convenience of workers trying to identify adult *Forcipomyia* material. The table to the subgenera presented by Saunders (1956) and the key in Dessart (1963) are now incomplete because of the recent description of additional subgenera. There admittedly will be many difficulties in using this key because some subgenera are most distinct in the male sex, others in the female. The subgeneric classification of *Forcipomyia* is based primarily on the relatively good characters of the immature stages, and identification of the adults probably will always be difficult.

Key to the Subgenera of *Forcipomyia*
(for adults, primarily females)

1\. Female antenna with distal 6 segments elongated; empodium large and broad, adapted for clinging to wings of insects; TR 3.0 or more ... *Pterobosca* Macfie

– Female antenna with distal 5 segments, if any, elongated, rarely distal 6; empodium not greatly enlarged or modified; TR 0.4–3.2 ... 2

2\. Palpus 4-segmented, only 1 segment distal to the 3rd (which bears the sensory organ) ... 3

– Palpus 5-segmented (segments 4 and 5 incompletely fused and non-articulated in *Euprojoannisia*) ... 8

3\. Female with 2 large functional spermathecae ... 4

– Female with one large functional spermatheca ... 6

4\. Body with deep greenish or bluish subcutaneous pigmentation, especially in abdomen ... *Caloforcipomyia* Saunders (part)

– Body without greenish or bluish subcutaneous pigmentation ... 5

5\. Female antenna with 5 distal segments greatly elongated, the proximal ones short and globular; TR 2.66–3.00 ... *Blantonia* Wirth and Dow

– Female antenna with distal segments not much longer than those in proximal series, all segments elongate tapering; TR about 2.0 ... *Metaforcipomyia* Saunders

6(4). Female antenna with 5 distal segments much longer than the short proximal segments; costa long, CR usually about 0.67; TR 1.3–1.75; female mandibular teeth well developed ... *Warmkea* Saunders

– Female antenna with distal segments not much longer than those in proximal series, all segments short ovoid to moderately long tapering; costa variable; TR variable; mandibular teeth not developed ... 7

7\. Basitarsi short, TR about 1.0; costa short, CR less than 0.5 ... genus A near *Lepidohelea* Kieffer

– Basitarsi elongate, TR about 2.0; costa short or moderately long ... *Saliohelea*, new subgenus

8(2). Female antennal segments of proximal series much shorter than distal 5, compressed, usually transverse 9

– Female antennal segments of proximal series not much shorter than distal segments, usually not compressed 12

9. Costa extending to well beyond middle of wing; 2nd radial cell much longer than 1st, very narrow; 1 subspherical spermatheca present, this without neck; female sucking vertebrate blood *Lasiohelea* Kieffer

– Costa usually ending at or near middle of wing; 2nd radial cell not unusually long and narrow; 2 spermathecae with distinct necks present; not known to suck vertebrate blood 10

10. Second and 3rd palpal segments stout, 3rd with scattered sensilla or shallow pit; mandible with proximal teeth very strong; male empodium present; male parameres U-shaped *Rhynchoforcipomyia* Wirth and Dow

– Third palpal segment with definite, deep sensory pit; mandibular teeth small and more uniform; male empodium and parameres various 11

11. Females suck blood from insects; male empodium present; male parameres U-shaped; larvae breed in moss and wet wood *Trichohelea* Goetghebuer

– Female feeding habits unknown; male empodium usually absent; male parameres H-shaped; larvae breed in plant leaf axils *Phytohelea* Remm

12(8). Fourth and 5th palpal segments incompletely fused, immovable; smalled, unmarked, brownish midges; TR greater than 1.0 *Euprojoannisia* Brèthes

– Fourth and 5th palpal segments distinctly separated, articulated; size, color, and TR various 13

13. Palpus with 3rd segment broadly swollen to past middle, usually nearly to tip, with sensory pit deep, extending nearly to base of segment; slender, hyaline, peglike, sensory spines present on surface near sensory pore; TR usually less than 0.5; large species, females suck insect blood *Microhelea* Kieffer

– Palpus various, 3rd segment rarely swollen past midlength and not bearing peglike sensory spines on surface near sensory pore; TR usually more than 0.5; size and habits various 14

14. Body usually with metallic jade green or deep blue subcutaneous pigmentation; antenna unusually elongate and slender; palpus slender; TR 1.36–2.32; wing and body often with ornate color pattern *Caloforcipomyia* Saunders (part)

– Body without greenish or bluish subcutaneous pigmentation; antenna usually much shorter; palpus, TR and coloration various 15

15. Small grayish or brownish unmarked species; TR usually greater than 2.0; antenna short, proximal segments subspherical, gradually more elongated distally; 1 spermatheca present 16

– Larger species, often with conspicuous markings on body, legs or wings; TR usually about 1.0 (0.5–1.5); 2 well-developed spermathecae present 17

16. Male genitalia with club-shaped parameres extending caudad from basistylar apodemes *Synthyridomyia* Saunders

– Male genitalia without club-shaped parameres *Thyridomyia* Saunders

17. Body with conspicuous, numerous, flattened scales in addition to normal setae and hairs; male genitalia with parameres not joined or fused at bases, dististyle elongate, sinuate with distinct distal expansion *Lepidohelea* Kieffer

– Body usually without scales, or if present they are usually not broad; male genitalia with parameres joined or fused at bases, dististyle not expanded distally 18

18. Male genitalia with aedeagus V-shaped, bearing a pair of small, sharp processes at tip *Schizoforcipomyia* Chan and LeRoux

– Male genitalia with aedeagus shield-shaped, with low basal arch *Forcipomyia,* s. str.

Forcipomyia (*Saliohelea*) *leei* Wirth and Ratanaworabhan, new species

Fig. 1

Female.—Wing length 0.62 mm; breadth 0.26 mm.

Head: Brownish, palpus paler. Proboscis (Fig. 1f) short. Antenna (Fig. 1b) with lengths of flagellar segments in proportion of 17-15-15-16-17-17-17-19-25-23-22-20-28; antennal ratio 0.89; segment 11 unusually long and segments 12–14 becoming progressively shorter; segments 4–10 subspherical to slightly elongate, 5 distal segments distinctly tapering to slender distal portions; 15 with distinct terminal papilla. Palpus (Fig. 1a) 4-segmented; lengths of segments in proportion of 10-12-38-23; PR 2.2; 3rd segment ovoid with shallow, round, sensory pit; 4th segment markedly tapered to slender tip. Mandible without visible teeth.

Thorax: Dark brown, pleuron paler. Legs (Fig. 1k) variably brownish to pale yellowish; with sparse setae and 1-striped slender scales; no broad scales; hind tibial comb as in Fig. 1h. Tarsi (Fig. 1l) unmodified; hind TR 2.7. Empodium (Fig. 1g) well developed; claws curved, moderately

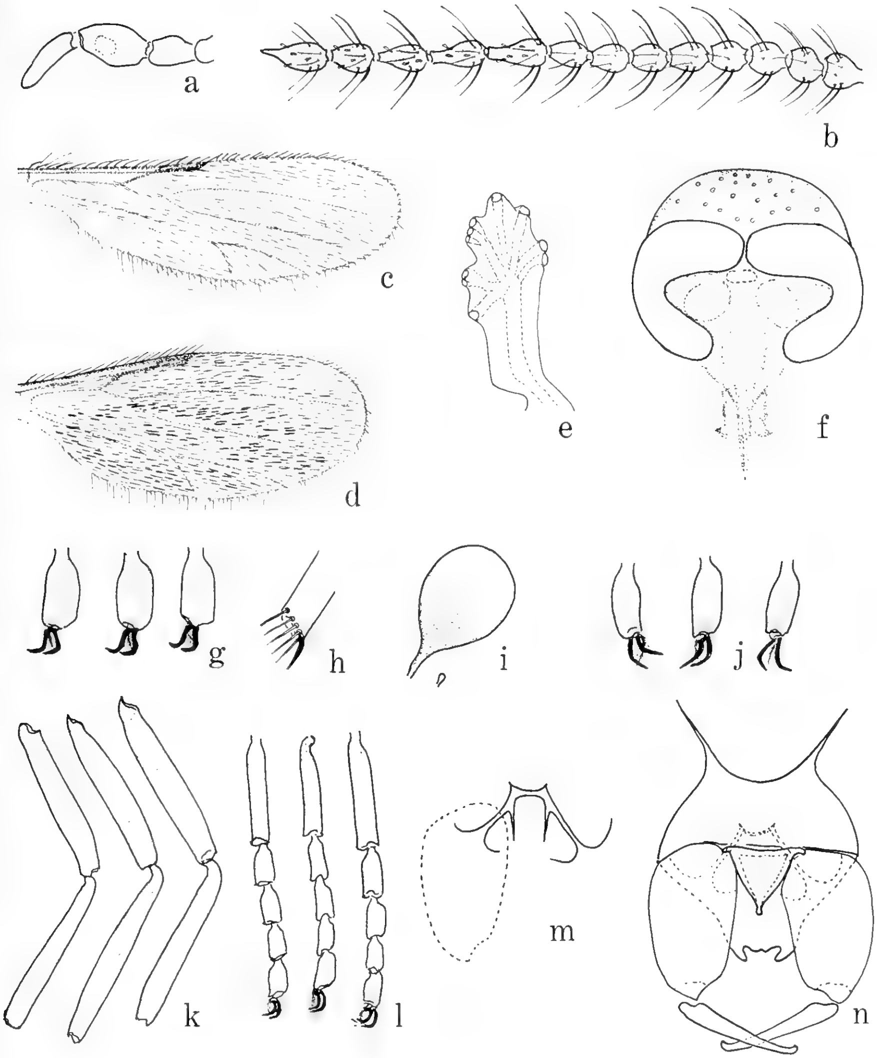

Fig. 1. *Forcipomyia* (*Saliohelea*) *leei.* a, female palpus; b, female antenna; c, male wing; d, female wing; e, pupal respiratory horn; f, female head; g, female fifth tarsomeres and claws of (left to right) front, middle and hind legs; h, hind tibial comb; i, spermatheca; j, male claws of (left to right) front, middle and hind legs; k, femora and tibia, of (left to right) hind, middle and front legs of female; l, tarsi of (left to right) hind, middle and front legs of female; m, male parameres; n, male genitalia, parameres removed.

stout. Wing (Fig. 1d) pale brownish due to moderately large microtrichia; macrotrichia especially long and coarse, decumbent, resembling slender, 1-striped scales; 1st radial cell obsolete, 2nd long and narrow; CR 0.52. Halter brownish.

Abdomen: Brownish, terga dark brown; last segment yellowish. Spermatheca as in Fig. 1h; one large ovoid functional spermatheca with long slender neck, usually with a minute irregularly tubular rudimentary spermatheca present; functional spermatheca measuring 0.052 by 0.030 mm including neck.

Male.—Wing length 0.64 mm; breadth 0.25 mm. Similar to female with usual sexual differences. Antenna with lengths of flagellar segments in proportion of 20-16-17-19-16-16-18-20-20-58-35-27-39; plume moderately long and dense, brownish; segments with 7–10 fused. Wing (Fig. 1c) with macrotrichia sparser than in female; CR 0.60. Hind TR 2.5; hind basitarsus slightly enlarged and darkened. Empodium moderately developed; claws (Fig. 1j) more slender than in female, without bifid tips.

Genitalia (Fig. 1n): Ninth sternum short with long anterolateral projections; 9th tergum short and tapering to moderately separated, setose, apicolateral lobes. Basistyle simple, about 2× as long as broad; dististyle long and slender, nearly straight, tapering to slightly bent, pointed tip. Aedeagus triangular in ventral view, basal margin transverse or nearly so, with short anterolateral processes; proximal and lateral margins all with similar internal sclerotized thickening; apex with distinct slender terminal papilla. Parameres (Fig. 1m) with diagonal basal apodemes connected by a well-developed transverse connective, slightly arcuate, the concave side anteriad; a short pair of slender, pointed processes projecting caudad from junction of apodeme and transverse connective, the length of these processes slightly variable, but usually less than length of aedeagus.

Pupa.—Length 1.7 mm. Color pale ochreous throughout. Head with a prominent tubercle at each anterolateral angle of antennal cases; a single low papilla and 2 pairs of minute spines on medium triangle; a small inconspicuous papilla on each lateral triangle. Thorax with 3 pairs of bulbous papillae on dorsum, and 1 minute pair at base of posterior prolongation, the latter extending across 1st abdominal segment. Prothoracic respiratory horn (Fig. 1e) very distinctive; with posterior basal shoulder similar to that of *Euprojoannisia*; distal portion enlarged, with 6 double or triple spiracular papillae arranged at intervals around margin giving a crinate appearance; tracheae of each papilla radiating from central felt chamber. Abdomen with many microchaetae on all surfaces of each segment; no large spines. Terminal abdominal processes long and slender, 1.5× length of basal portion of 9th segment; male appendages dorsal, very short, each with a small lateral spine.

Distribution.—Eastern U.S.A., Neotropical Region to southern Brazil.

Types.—Holotype, ♀, Rio Raposo, Valle, Colombia, June–July 1963, V. H. Lee (Type no. 70440, USNM). Allotype, ♂, same data but July 1965, in light trap.

Paratypes, 43 ♂ and 35♀ as follows: COLOMBIA: Rio Raposo, Valle, Jan.–Dec. 1963–1965, V. H. Lee, light trap, 22 ♂, 18♀. Rio Anori, Antioquia, Sept. 1970, D. G. Young, light trap in rain forest, 2 ♂, 2♀. BRAZIL: Belem, Para, April 1970, T. H. G. Aitken, light trap, 1♂. Nova Teutonia, Santa Catarina, Sept. 1961, F. Plaumann, 1♀. Rio de Janeiro, 31 July 1923, L. G. Saunders, reared from beneath bark of fallen tree in forest, 1♂ and associated pupal exuviae. Rio Preto, Amazonas, 7 June 1962, E. J. Fittkau, at light, 1♂. TRINIDAD: No locality, Aug. 1963, R. W. Williams, reared from rotting cacao pods, 1 ♂, 4♀. DOMINICA: Cabrit Swamp, 23 Feb. 1965, W. W. Wirth, 1 ♀. Central Forest Reserve, 11 May 1968, P. C. Drummond, black light, 1♀. d'Leau Gommier, 17 March 1956, J. F. G. Clarke, 1♂. Fond Figues River, 11 Feb. 1965, W. W. Wirth, rain forest, 1♂. Pont Casse, April 1964, O. S. Flint, at light, 1 ♂, 1 ♀; same, 12 Feb. 1965, W. W. Wirth, rain forest, 2♀. PUERTO RICO: El Verde, Barrio Rio Grande, G. E. Drewery, sticky trap, 1 ♀. Mayaguez, Univ. Puerto Rico Campus, 13 Aug. 1969, T. Walker and P. Drummond, 1♀. JAMAICA: Hardwar Gap, 10 May 1970, W. W. Wirth and T. Farr, malaise trap, 3♂, 2♀. U.S.A.: FLORIDA: Alachua Co., Gainesville, June 1967, F. S. Blanton, light trap, 2 ♂, 1♀. Jefferson Co., Monticello, Oct. 1969, W. H. Whitcomb, light trap, 1♂. Leon Co., 3 mi N Tallahassee, May 1970, F. S. Blanton, light trap, 1 ♂. Marion Co., Juniper Springs, 28 Apr. 1970, W. W. Wirth, light trap, 1 ♂. Orange Co., Lake Magnolia Park, 6 Aug. 1970, E. Irons, light trap, 1 ♀. SOUTH CAROLINA: Georgetown Co., Hobcaw House, 20 Apr. 1972, Mrs. L. Henry, light trap, 2 ♂. VIRGINIA: Fairfax Co., Falls Church, Holmes Run, 7 Sept. 1961, W. W. Wirth, light trap, 1 ♂. NEW YORK: Newcomb, Lake Harris, 19 Aug. 1972, L. Knutson, malaise trap, 1 ♂.

Etymology.—This species is named for Vernon H. Lee in recognition of his extensive contributions to our knowledge of Colombian biting midges. Dr. Lee collected ceratopogonids extensively for us in Colombia as a member of a Rockefeller Foundation arbovirus research team.

Discussion.—*Forcipomyia leei* is closely related to the African species *F. stami*, new species, with differences as discussed under that species. *Forcipomyia leei* is a very widespread species, occurring from the northeastern United States to southern Brazil and, as might be expected, varies somewhat in leg color and in the length of the posterior processes of the male parameres. We have been unable to correlate this variation with geographical distribution or other factors and conclude that our material is conspecific.

Forcipomyia (*Saliohelea*) *stami* Wirth and Ratanaworabhan, new species

Fig. 2

Female.—Wing length 0.66 mm; breadth 0.34 mm.

Head: Brown, including palpi and antennae. Antenna (Fig. 2a) with lengths of flagellar segments in proportion of 20-14-15-15-15-16-17-20-26-27-27-24-34; antennal ratio 1.00; segments 4–10 progressively globular to short tapering, 11–14 moderately elongate, tapering. Palpus (Fig. 2d) with lengths of segments in proportion of 14-13-36-34; 3rd segment ovoid with large, round, shallow sensory pit; PR 1.9; 4th segment tapering to moderately slender tip. Mandible without visible teeth.

Thorax: Dark brown, pleuron slightly paler. Legs yellowish, distal tarsomeres slightly infuscated; hind tibial comb (Fig. 2c) with 5 subequal setae; hind TR 1.86; empodium well developed; claws slender and curved, pointed distally (Fig. 2f). Wing (Fig. 2b) pale brownish due to moderately large microtrichia; macrotrichia long and coarse, 1-striated, moderately dense, without color pattern; 1st radial cell obsolete, 2nd slitlike; costa exceptionally short, CR 0.41. Halter brownish.

Abdomen: Brownish including terminal segments and cerci. Spermathecae (Fig. 2e): 1 large ovoid functional spermatheca with long slender neck, measuring 0.058 by 0.032 mm; a tiny, ovoid, well-sclerotized, rudimentary spermatheca present.

Male.—Wing length 0.74 mm; breadth 0.25 mm; CR 0.44. Similar to female, with usual sexual differences. Hind TR 1.90.

Genitalia as in Fig. 2h: Ninth sternum moderately short, with distinct caudomedian excavation; 9th tergum tapering to rather closely approximated apicolateral lobes. Basistyle rather slender; dististyle straight to slender, slightly pointed tip. Aedeagus slightly longer than basal breadth; basal arch low; outline triangular in ventral view, the sides moderately sclerotized with a thinner, slightly concave, marginal rim; apex produced slightly in a slender terminal papilla. Parameres (Fig. 2g) with slender, diagonal basal apodemes joined mesally in a short, quadrate, transverse connective; no trace of submedian caudal processes from this platelike connective.

Distribution.—Zaire.

Types.—Holotype, ♀, allotype, ♂, Zaire, Coquilhatville, March–April 1972, A. B. Stam (Type no. 17305, USNM).

Paratypes, 2 ♂, 1 ♀, same data.

Etymology.—This species is named for its collector, Professor A. B. Stam, Director of the Institute of Entomology and Parasitology of Africa, Kumasi, Ghana, in recognition of his keen interest in the taxonomic study of African biting midges.

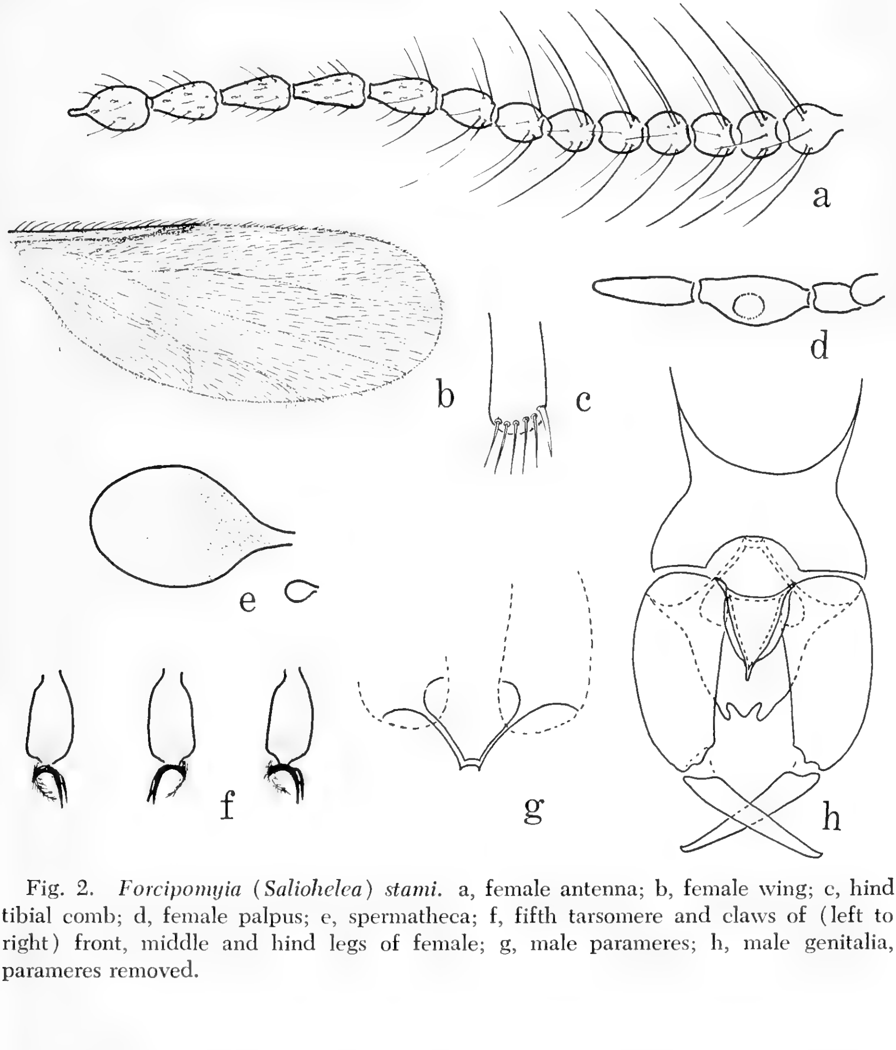

Fig. 2. *Forcipomyia* (*Saliohelea*) *stami.* a, female antenna; b, female wing; c, hind tibial comb; d, female palpus; e, spermatheca; f, fifth tarsomere and claws of (left to right) front, middle and hind legs of female; g, male parameres; h, male genitalia, parameres removed.

Discussion.—Forcipomyia stami is closely related to the American *F. leei*, appearing almost identical to some variants of *leei*, but differing as follows: In *stami* the costa is shorter, the distal antennal segments are longer, the hind basitarsus is shorter and the posterior processes are lacking in the male parameres. The latter character causes a problem with the subgeneric diagnosis, but occasional variation of the same character in the related subgenus *Euprojoannisia* shows the same instability and is not considered critical to subgeneric recognition.

Forcipomyia (*Saliohelea*) *brevicosta* (Clastrier)
Fig. 3

Lasiohelea brevicosta Clastrier, 1960:520 (♀; Congo; fig. wing, antenna, palpus).

Forcipomyia (subgenus C) *brevicosta* (Clastrier); Dessart, 1963:47 (redescribed; compared with *deminuta* T. & M.; combination).

Female.—Wing length 0.83 mm; breadth 0.33 mm.

Head: Brown. Antenna (Fig. 3a) with lengths of flagellar segments in proportion of 25-20-20-20-20-21-23-25-37-37-40-40-53; AR 1.20; distal 5 segments distinctly more elongate than in *F. leei*, without the peculiar shortening of the subapical segments. Palpus (Fig. 3b) with lengths of segments in proportion of 10-15-36-34; 3rd segment without definite sensory pit; palpal ratio 2.1 (Clastrier's figure shows the 3rd palpal segment stouter, with palpal ratio 1.8).

Thorax: Dark brown. Legs uniformly yellowish brown; hind TR 1.83 (2.0 in holotype according to Clastrier), much lower than the TR of 2.7 found in *F. leei*; hind basitarsus not swollen. Tibial comb as in Fig. 3d, 5th tarsomeres and claws as in Fig. 3f. Wing (Fig. 3c) with CR 0.48; macrotrichia broader than in *F. leei*, more scalelike with up to 3 or 4 striations, compared with a maximum of 1 stripe in *F. leei*. Halter brown.

Abdomen: Uniformly brown. Spermatheca (Fig. 3e) ovoid to pyriform, tapering to duct; without the slender neck found in *F. leei*; measuring 0.058 by 0.033 mm; a minute, oval, rudimentary 2nd spermatheca present.

Male.—As in the female with the usual sexual differences. Genitalia (Fig. 3h) with 9th segment similar to those of *F. leei*. Basistyle moderately slender, slightly curved; dististyle slightly more slender and more curved than in *leei*. Aedeagus about as broad as long, basal arch low, basal arms stout and scarcely differentiated; distal portion cleft a short distance in a contiguous pair of short, curved, strongly sclerotized processes. Parameres (Fig. 3g) with long, slender, oblique basal apodemes, anterior connective short, bearing a posterior pair of long, curved, moderately stout, strongly sclerotized posterior processes, their apices slightly crossed on midline just distad of tip of aedeagus.

Distribution.—West Africa (Rep. Congo, Nigeria).

Type.—Holotype, ♀, Nuku N'Situ, Rep. Congo, May 1956, R. Taufflieb, (in Inst. Pasteur d'Algerie, Algiers).

Material examined.—NIGERIA: Redescribed from 5 ♂, 2 ♀, Ibadan, Aug. 1962, D. C. Eidt, malaise trap (through Canadian National Collection, Ottawa).

Discussion.—The present material agrees well with Clastrier's original description, except as noted above. The most important differences from

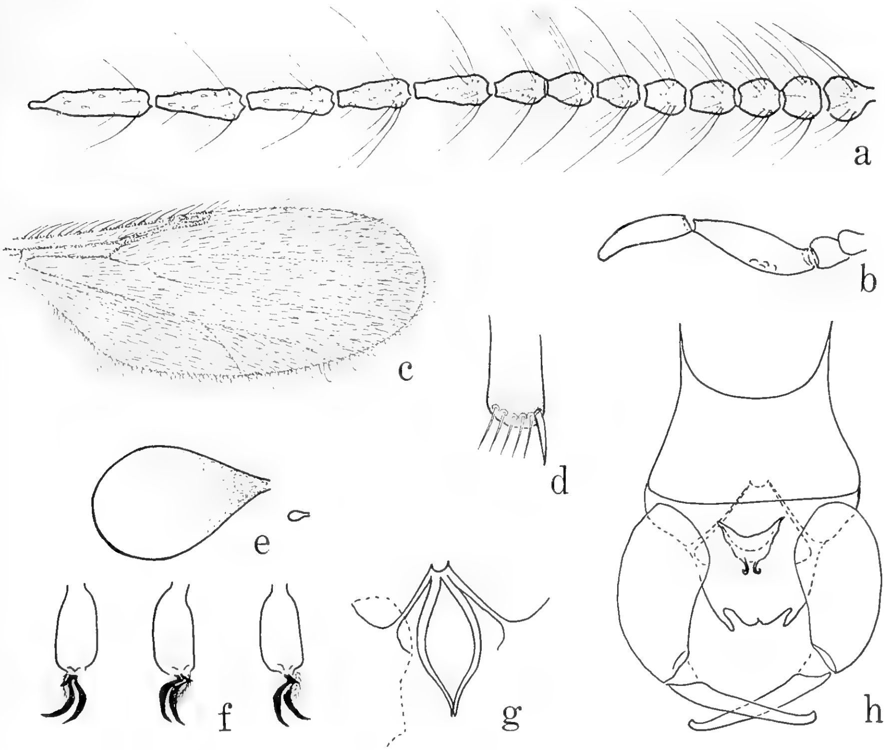

Fig. 3. *Forcipomyia* (*Saliohelea*) *brevicosta.* a, female antenna; b, female palpus; c, female wing; d, hind tibial comb; e, spermatheca; f, fifth tarsomere and claws of (left to right) front, middle and hind legs of female; g, male parameres; h, male genitalia, parameres removed.

F. leei, which while still permitting assignment to the subgenus *Saliohelea* require a slight adjustment in the subgeneric concept, are the more elongate distal antennal segments, the lack of a sensory pit on the third palpal segment, the more elongate, curved parameres and the distinctly cleft tip of the male aedeagus.

Forcipomyia (*Saliohelea*) *deminuta* Tokunaga and Murachi

Forcipomyia (subgenus C) *deminuta* Tokunaga and Murachi, 1959:219 (♂, ♀; Palau and Caroline Islands; figs.).

Female.—Wing length 0.62 mm; breadth 0.25 mm. A tiny, uniformly pale yellowish-brown species without distinctive markings. Antenna with all flagellar segments short tapering, lengths in proportion of 10-8-8-8-8-9-9-

9-9-9-9-10-15; AR 0.78. Palpal segments with lengths in proportion of 4-10-24-19; PR 2.6; 3rd segment slightly swollen at base, slender distally, with an indistinct, small, shallow, round sensory pit at midlength; 4th segment quite slender, slightly narrowed on distal portion. Mandible without visible teeth. Legs with TR 2.2 on front leg, TR 1.71 on middle leg, and TR 1.67 on hind leg; tarsi with numerous 1–3 striped, slender, scalelike hairs. Wing with CR 0.48. Halter pale yellowish. Abdomen yellowish; spermatheca single, ovoid, tapering to slender neck (Tokunaga and Murachi's figure showing two spermathecae is apparently in error; it was stated to be single in their description).

Male.—Wing length 0.80 mm; breadth 0.24 mm. As in female with usual sexual differences; CR 0.47; TR 2.38 on front leg, 1.81 on middle leg, and 1.81 on hind leg; hind basitarsus distinctly swollen. Genitalia with aedeagus small and triangular without well-developed basal arch or lateral arms, the anterior and lateral margins with distinct narrow internal sclerotization (not shown in Tokunaga and Murachi's figure); median distal process slender, peglike. Parameres with diagonal basistylar apodemes, the sclerotization of the median connective indistinct and poorly visible (shown as quite extensive in Tokunaga and Murachi's figure); posterior processes not visible.

Distribution.—Micronesia, Philippines.

Types.—Holotype, ♂, allotype, ♀, Mt. Temwetemwensekir, Ponape, Caroline Islands, 180 m, 19 Jan. 1953, J. L. Gressitt (in Bishop Museum, Honolulu).

Material examined.—CAROLINE ISLANDS: 2 ♂, same data as types (in USNM). PHILIPPINE ISLANDS: 7 ♀, Mindanao, Mt. Apo, Davao Prov., 15 Nov. 1947, H. Hoogstraal and F. Werner (Chicago Nat. Hist. Mus. and USNM).

Discussion.—This species was well illustrated by Tokunaga and Murachi (1959). The Philippine material conforms closely to the original description of the female from Micronesia, and we add this new distribution without hesitation.

Acknowledgment

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(WWW) Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. and Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560; and (NCR) Applied Scientific Research Corporation, Bangkok, Thailand.

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APHIDS OF SUNFLOWER: DISTRIBUTION AND HOSTS IN NORTH AMERICA (HOMOPTERA: APHIDIDAE)[1]

C. E. Rogers, T. E. Thompson and M. B. Stoetzel

Abstract.—Distribution and host data are given for aphids on 15 species of *Helianthus* collected in the United States in 1976 and 1977. Aphids of the genus *Dactynotus* were found primarily on eastern perennial species of *Helianthus*. *Aphis helianthi* Monell and *Masonaphis masoni* (Knowlton) were found mostly on western annual species of *Helianthus*. A summary of previous records for aphids on *Helianthus* is also given.

Little is known about the bionomics or effects of aphids on sunflower. Rogers et al. (1972) reported that *Aphis helianthi* Monell on *Helianthus annus* L. served as a good alternate host for parasitoids released to control the greenbug, *Schizaphis graminum* (Rondani), on sorghum. Most reports of aphids on sunflower have been included in regional surveys (Williams, 1910; Hottes and Frison, 1931; McGillivray, 1958; Leonard, 1959; Palmer, 1952; Leonard and Tissot, 1965; Leonard, 1968; and Olive, 1963) and taxonomic studies (Olive, 1965). Some of the aphids that are known from sunflower are well-known vectors of virsuses (Kennedy et al., 1962).

Sunflower has become an important oilseed crop in the United States. Because of the importance of aphids as pests on other crops (Gibson and Plumb, 1977), this study was designed to determine the species and abundance of aphids on native *Helianthus* species.

Materials and Methods

Two of us (CER and TET) drove about 24,000 km in the southern half of the United States in 1976 and 1977 and collected native species of *Helianthus* and associated aphids. We paid particular attention to the effect of the aphids on their host plants. Aphids were collected in 70% ethyl alcohol for subsequent sorting and identification. Plants were identified *in situ* according to Heiser (1969). Specimen mounts of plants were also prepared and later confirmed by Dr. C. B. Heiser, Jr. MBS identified the aphids, and voucher specimens have been placed in the U.S. National Museum Collection at Beltsville, Maryland.

Results and Discussion

Some species of aphids reported from sunflower normally use other genera as primary hosts (Table 1). For example, *Aphis gossypii* Glover

Table 1.—Aphids known from *Helianthus* species in North America.

Aphid species	*Helianthus* host[a]	Location	Authority
Aphis armoraciae Cowen	*pumilis* Nuttall (P)	Rocky Mtns.	Palmer (1952)
A. debilicornis (Gillette & Palmer)	*annuus* (A)	Rocky Mtns.	Palmer (1952)
	grossesserratus Martens (P)	MO	Leonard (1963)
	tuberosus L. (P)	Rocky Mtns.; MO	Palmer (1952) Leonard (1959)
A. gossypii Glover	cultivar (A)	TX	Leonard & Tissot (1965)
	species (?)	TX	Leonard & Tissot (1965)
A. helianthi Monell	*annuus*	Rocky Mtns.; KS	Palmer (1952); Walker (1936)
	petiolaris Nuttall (A)	Rocky Mtns.	Palmer (1952)
	tuberosus	MO	Leonard (1963)
	species (?)	KS; MO; NE; OK; Rocky Mtns.; TX	Walker (1936); Leonard (1963); Williams (1910); Rogers et al. (1972); Palmer (1952); Leonard and Tissot (1965)
Bipersona ochrocentri (Cockerell)	*annuus*	MO	Leonard (1962)
Dactynotus ambrosiae (Thomas)	*annuus*	Rocky Mtns.	Palmer (1952)
	grosseserratus	MO	Leonard (1963)
	species (?)	TX; (?)	Leonard & Tissot (1965); Olive (1965)
	tuberosus	MO	Leonard (1963)
D. helianthicola Olive	*atrorubens* L. (P)	NC	Olive (1963)
	microcephalus Torrey & Gray (P)	NC	Olive (1963)
	strumosus L. (P)	NC	Olive (1963)
	tuberosus (P)	NC	Olive (1963)
	species (?)	TX	Leonard & Tissot (1965)
D. illini (Hottes & Frison)	species (?)	(?)	Olive (1965)

[a] A = annual; P = perennial

Table 1.—*Continued.*

Aphid species	*Helianthus* host[a]	Location	Authority
D. obscuricaudatus Olive	*strumosus*	PA	Olive (1965)
D. parvtotubercultus Olive	*atrorubens*	NC	Olive (1965)
D. pseudambrosiae Olive	*microcephalus*	NC	Olive (1965)
D. rudbeckiae (Fitch)	species (?)	TX	Leonard & Tissot (1965)
D. ruralis (Hottes & Frison)	species (?)	?	Olive (1965)
Dactynotus sp.	*grosseserratus*	MO	Leonard (1959)
	tuberosus	MO	Leonard (1963)
Macrosiphum euphorbiae (Thomas)	*annuus*	Rocky Mtns.	Palmer (1952)
	species (?)	Rocky Mtns.	Palmer (1952)
Macrosiphum sp.	*tuberosus*	MO	Leonard (1959)
Masonaphis masoni (Knowlton)	*annuus*	(?)	MacGillivray (1958)
	species (?)	(?)	MacGillivray (1958)
	species (?)	CO	Palmer (1952)
Prociphilus erigeronensis (Thomas)	*annuus*	Rocky Mtns.	Palmer (1952)
	species (?)	CO	Palmer (1952)

(cotton aphid) and *Macrosiphum euphorbia* (Thomas) (potato aphid) are common pests on the crops indicated by their common names. Also, the species names for *Aphis amoraciae* Cowen, *Dactynotus ambrosiae* (Thomas), *D. rudbeckiae* (Fitch), and *Prociphilus erigeronensis* (Thomas) implicate genera other than *Helianthus* as the primary host plants for these aphids. The published records suggest that *Aphis* species commonly colonize annual species of *Helianthus*, whereas *Dactynotus* species colonize perennial species of *Helianthus*.

We collected 47 species of *Helianthus*, 15 of which harbored aphids (Table 2). Aphids were also collected from 'Hybrid 896' and from a cultivar of unknown parentage. Our data verified that *Dactynotus* species colonize primarily perennial *Helianthus* species and that other genera occur mostly on annual sunflowers. We have shown that several species of perennial *Helianthus* are resistant to *Masonaphis masoni* (Knowlton), a species that is common on *annuus* types and cultivated sunflower (Rogers and Thompson, 1978). Also, *Dactynotus helianthicola* Olive failed to survive in the laboratory when transferred from the perennial *H. occiden-*

Table 2.—Aphids collected from *Helianthus* species in the United States during 1976 and 1977.

Aphid species	*Helianthus* host[a]	Location
Aphis deblicornis (Gillette & Palmer)	*nuttallii* Torrey & Gray (P)	CO
A. helianthi Monell	*annuus* (A)	AR; CA; CO; KS; NM; NV; TX; UT
	neglectus Heiser (A)	NM
	petiolaris (A)	CO
	Hybrid 896 (A)	TX
Dactynotus ambrosiae (Thomas)	*petiolaris*	CO
D. helianthicola Olive	*heterophyllus* Nuttall (P)	MS
	tuberosus (P)	OK; SC
	microcephalus (P)	AL
	occidentalis (P)	MO
	longifolius Pursh (P)	AL
	atrorubens (P)	NC
	silphioides Nuttall (P)	OK
Dactynotus sp.	*argophyllus* Torrey & Gray (A)	TX
	grosseserratus (P)	TX
	maximiliani Schrader (P)	TX
	petiolaris	NM
	tuberosus	TX
Macrosiphum euphorbiae (Thomas)	*petiolaris*	CO
	cultivar	CA
	Hybrid 896	TX
Masonaphis masoni (Knowlton)	*paradoxus* Heiser (A)	TX
	Hybrid 896	TX
	nuttallii (P)	CO
Myzus persicae (Sulzer)	cultivar	CA
	Hybrid 896	TX
Rhopalosiphum sp.	*annuus*	NM
	Hybrid 896	TX

[a] A = annual; P = perennial

talis Riddell to Hybrid 896. These narrow host preferences among sunflower aphids become very important in the development of aphid-resistant sunflower hybrids.

The host and distribution data shown in Table 2 (but not in Table 1) probably represent new records. For the most part, *Dactynotus* species were found primarily on eastern perennial species of *Helianthus,* and *A. helianthi* mostly on western annual species of *Helianthus. Dactynotus* species feed mainly on the upper stems and leaf petioles of sunflower. *Aphis helianthi* and *M. masoni* feed mainly on lower leaf surfaces and on the underside of receptacles. *Macrosiphum euphorbia* feeds on the terminal of plants and on ray flowers around the receptacle. One alate *Hysteronuera setariae* (Thomas) adult was found on *H. microcephallus* Torrey and Gray in North Carolina, probably as a result of an accidental landing.

Acknowledgments

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(CER and TET) Southwestern Great Plains Research Center, Fed. Res., Sci. and Educ. Admin., USDA, Bushland, Texas 79102; and (MBS) Systematic Entomology Laboratory, Fed. Res., Sci. and Educ. Admin., USDA, Beltsville, Maryland 20705.

Footnote

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80(4), 1978, pp. 514–516

A NEW SPECIES OF *ASPHONDYLIA* (DIPTERA: CECIDOMYIIDAE) FROM COSTA RICA WITH TAXONOMIC NOTES ON RELATED SPECIES

Raymond J. Gagné

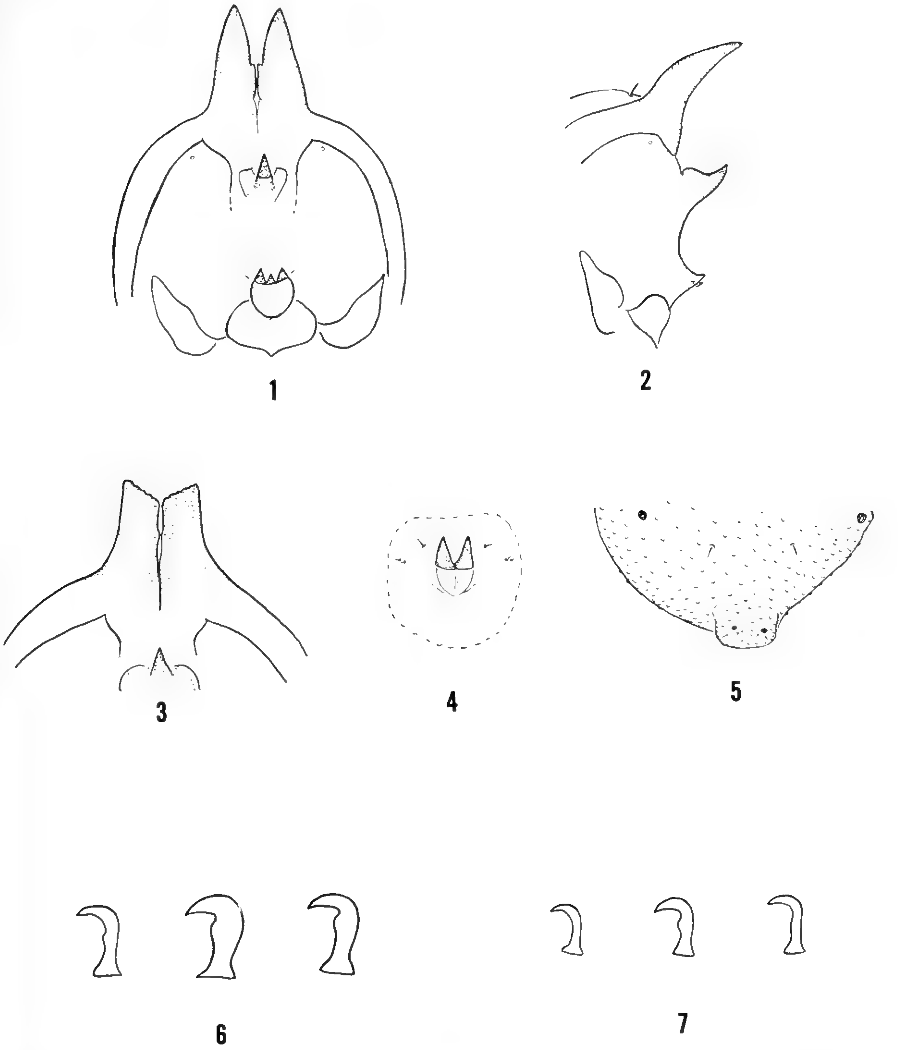
Abstract.—A new species, *Asphondylia enterolobii,* a gall former on *Enterolobium cyclocarpum* in Costa Rica, is described with illustrations. It and its closest congeners form bud and pod galls on various Mimosaceae. *Hemiasphondylia* Möhn is synonymized under *Asphondylia* and *H. mimosae,* preoccupied in *Asphondylia,* is renamed *Asphondylia mimosicola* Gagné.

This paper was intended to be simply a description of a new species, the subject of a biological study now in progress in Costa Rica. But searching a large genus for close relatives of a species often uncovers taxonomic complications as well as leads to interesting realizations of systematic relationships as related below.

The new species, *Asphondylia enterolobii,* was reared from flower galls on *Enterolobium cyclocarpum* (Jacq.) Griseb. (Mimosaceae) in Costa Rica. Specimens were submitted for identification by Dr. D. H. Janzen of the University of Pennsylvania, Philadelphia, who is interested in the biology of the gall midge in view of its apparently devastating effect on the host's seed crop production.

Interestingly, the three species most closely related to *A. enterolobii* have been reared from Mimosaceae also: *Asphondylia mimosae* Felt from bud and pod galls on *Mimosa* sp. (undet.) in Texas; *Hemiasphondylia mimosae* Möhn on bud and pod galls of *Mimosa albida* H. & B. in El Salvador; and *Asphondylia prosopidis* Cockerell from buds of *Prosopis glandulosa* Torr. in New Mexico and Texas. The four gall midge species share the derived character states of a reduced shaft of the larval spatula, the development of a pair of corniform setae on the terminal segment of the larval abdomen and anisomorphic tarsal claws. The pupae of all are similar in that they have a simple upper frontal crest and a trifid lower one, this with the medial point shortest.

Möhn (1960) erected *Hemiasphondylia* for his new species *mimosae* on the basis of the characters listed above and the fact that the sternal spatula of *mimosae* is bifid, a condition that does not obtain in *prosopidis.* I see no practical reason for segregating *H. mimosae* and the other species on Mimosaceae from *Asphondylia* and so consider *Hemiasphondylia* a synonym of *Asphondylia. Asphondylia mimosae* (Möhn), new combination, is consequently a secondary homonym and is renamed here *A. mimosicola* Gagné.



Figs. 1–2. Pupal head of *Asphendylia enterolobii* (ventral and lateral views, respectively). Fig. 3. Pupal head of *A. prosopidis* (ventral view). Figs. 4–7. *Asphondylia enterolobii.* 4, Larval spatula. 5, Larval terminal segments (dorsal). 6, Front, middle and hind claws of female. 7, Same, of male.

Asphondylia enterolobii Gagné, new species

Adult.—Habitus and terminalia as in other *Asphondylia.* Palpus 3-segmented. Legs covered with brownish scales, unbanded. Tarsal claws (Figs. 6–7) anisomorphic, middle claws largest, front claws smallest, at least middle and hind claws enlarged near middle.

Pupa.—Head (Figs. 1–2): Antennal horns conic, tapering to point without crenulations on anteromedial surface; upper frontal crest single, lower frontal crest trifid, lateral points longer than medial point.

Larva.—Sternal spatula (Fig. 4) bifid, shaft not developed. Terminal abdominal segment (Fig. 5) with 3 papillae per side, 2 with short setae, 1 with corniform seta.

Holotype.—Pupa, ex *Enterolobium cyclocarpum* gall, 10 March 1977, Santa Rosa National Park, Guanacaste Province, Costa Rica, D. H. Janzen, USNM Type No. 75229. Paratypes: 4 ♂, 2 ♀, 21 pupae and 6 larvae, all with same data as holotype (USNM).

Discussion.—*Asphondylia enterolobii* is the only one of the 4 related taxa with conical pupal horns. The other species have wider, less tapered horns shaped as in *A. prosopidis* (Fig. 3) with crenulations on the anteromedial edge. The larval spatula of *enterolobii* lacks a shaft; those of *mimosicola* and *prosopidis* are quadridentate. The larva of *mimosae* is unknown.

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Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. and Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

PROC. ENTOMOL. SOC. WASH.
80(4), 1978, pp. 517–519

NEW SYNONYMY AND A REVIEW OF *HAPLUSIA* (DIPTERA: CECIDOMYIIDAE)

Raymond J. Gagné

Abstract.—New synonymy of *Haplusia* is made to validate use of the name in a forthcoming key to the genera of Cecidomyiidae. *Chastomera*, *Palaeocolpodia* and *Johnsonomyia* are treated as junior synonyms, and a list is given of the species referable to *Haplusia*.

This paper is written mainly to report new synonyms and to validate the use of the name *Haplusia* Karsch that will be used in a forthcoming key to the genera of Nearctic Cecidomyiidae, but also to review the scattered writings concerning the genus. *Haplusia* contains 14 described and many undescribed species from all over the world and from Baltic amber. The venation is characteristic and distinct from the other genera of Porricondylinae, a subfamily of mycophagous cecidomyiids containing many genera of worldwide distribution. The rs crossvein is far distant from the wing base, R_5 bends abruptly at rm and joins C considerably caudad of the wing apex, and Cu is simple. All species of *Haplusia* lack antennal circumfila and most have very long palpi and well-marked wing spots and leg bands.

The proposed synonymy is as follows:

Haplusia Karsch, 1877:15, 16. Type-species, *plumipes* Karsch, by original designation.
Chastomera Skuse, 1888:112. Type-species, *bella* Skuse, by monotypy.
Palaeocolpodia Meunier, 1904:18. Type-species, *eocenica* Meunier, by monotypy. NEW SYNONYM.
Johnsonomyia Felt, 1908:417. Type-species *rubra* Felt, by original designation. NEW SYNONYM.

Rübsaamen (1892) was first to point out the similarity between the wing of *Haplusia plumipes* and that drawn for *Chastomera bella* by Skuse (1888) and to treat the 2 genera as synonyms; but his observation was ignored until recently when Panelius (1965) cited it but, not having seen specimens of *Chastomera*, declined to follow Rübsaamen. Dr. D. H. Colless, CSIRO, Canberra, Australia kindly sent me an Australian specimen he compared with the type of *Chastomera bella* and considered to be the same in obvious respects. The specimen has the same venation and general habitus as North American specimens of what has been known as *Johnsonomyia*. *Chastomera* was most recently used by Mamaev (1964, 1966), first as a senior synonym of *Johnsonomyia*, then as a genus distinct from the latter and distinguished on the basis of the eye bridge length, a character that I do not consider will necessarily distinguish natural subdivisions of the genus.

Palaeocolpodia eocenica Meunier is known from Baltic amber fossils with wings typical of the modern species. That an Eocene-Oligocene fossil can be congeneric with an extant genus is not surprising considering that such genera as *Lestodiplosis* and *Contarinia* were well established in the Oligocene-Miocene (Gagné, 1973). Mamaev (1964) also pointed out the resemblance of *Palaeocolpodia eocenica* to *Chastomera* and considered the 2 genera to be synonyms.

Haplusia may be separated into 2 or more genera someday, but that decision should best follow a study of the fauna on a world basis and not arbitrary splitting resulting from superficial study of limited material and narrow geographic scope.

Following is a list of species referable to *Haplusia*. *Haplusia bella* is a restored combination; all others except *plumipes* are new combinations.

alexanderi (Felt), 1921:96 (*Johnsonomyia*). "Cameroun."
bella (Skuse), 1888:112 (*Chastomera*). Australia.
braziliensis (Felt), 1915:153 (*Johnsonomyia*). Brazil.
brevipalpis (Mamaev), 1964:903 (*Chastomera*). Russia.
cincta (Felt), 1912:103 (*Johnsonomyia*). Guatemala.
eocenica (Meunier), 1904:18 (*Palaeocolpodia*). Baltic amber.
fusca (Felt), 1908:417 (*Johnsonomyia*). Eastern United States.
hondrui (Mamaev), 1964:902 (*Chastomera*). Rumania.
longipalpis (Mamaev), 1964:902 (*Chastomera*). Russia.
pallida (Mamaev), 1966:220 (*Johnsonomyia*). Eastern USSR.
palpata (Mamaev), 1966:219 (*Johnsonomyia*). Russia.
plumipes Karsch, 1877:16. Brazil.
rubra (Felt), 1908:417 (*Johnsonomyia*). Eastern United States.
spiculosa (Barnes), 1927:271 (*Chastomera*). Malaya.

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80(4), 1978, pp. 520–523

A NEW GENUS AND SPECIES OF CARDIASTETHINI FROM PERU (HEMIPTERA: ANTHOCORIDAE)

Thomas J. Henry and Jon L. Herring

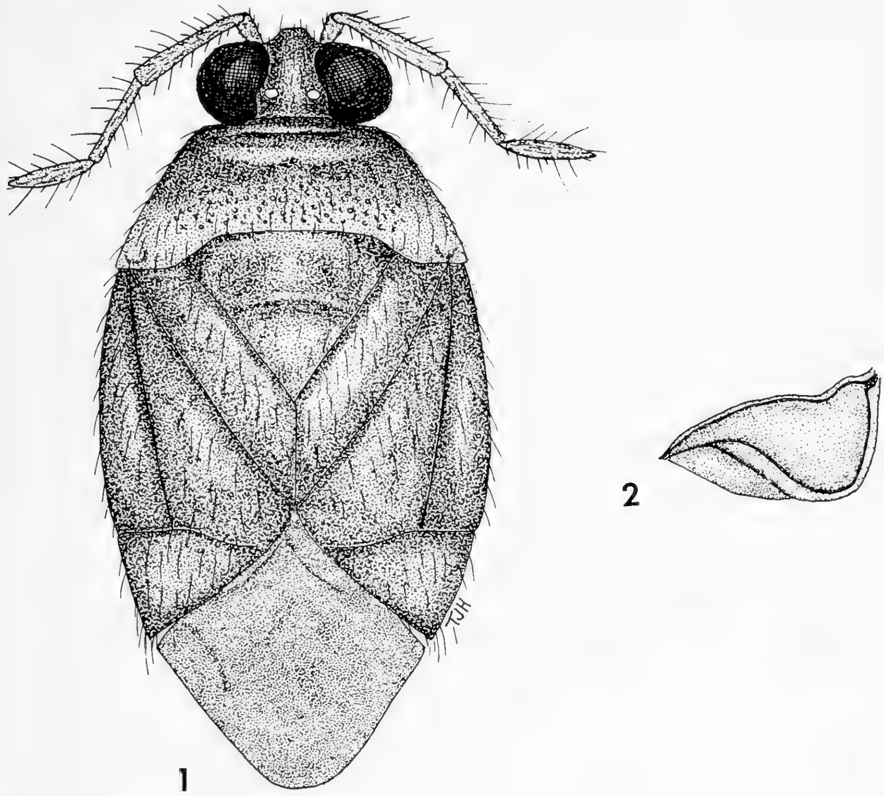
Abstract.—A new genus and species, *Dolostethus pubescens*, is described from the Pichis River region of Pasco, Peru. Its placement in the tribe Cardiastethini is discussed, and figures of the habitus of the adult male and the metapleural scent gland are included.

Recently, while searching for undetermined Isometopinae (Miridae) in the Cornell University collections, A. G. Wheeler, Jr. discovered an interesting and peculiar anthocorid. At first, this bug appeared to belong to the isometopines because of its large eyes, type of pronotum and other features. Upon closer examination, the single male specimen proved to be a new Neotropical genus and species of the tribe Cardiastethini in the anthocorid subfamily Lyctocorinae.

Dolostethus Henry and Herring, new genus

Description.—Characterized by the large eyes, narrow vertex, deeply emarginate posterior margin of the pronotum, distinctive fracture between the cuneus and membrane, and the unique character of scent gland canal.

Head wider than long, eyes large, granulate, not touching anterior margin of pronotum, dorsal width of eye much greater than width of vertex; ocelli set near posterior margin of head; tylus broad, truncate; rostrum short, not reaching beyond middle of sternum; antennae simple, thickly pubescent, segment I short, visible from dorsal aspect; segment II longest, thickest, gradually enlarged to apex; segments III and IV each greater than ½ length of II, their combined lengths 1.5× length of segment II, clothed with pilose setae, length of some more than 2× diameter of segments. Pronotum, width 3× length, subquadrate, collar weakly formed, anterior margin straight, lateral margins weakly rounded, distinctly carinate, posterior margin deeply sinuate, humeral angles bearing blunt nodes, calli narrow, shiny, smooth, rugose between; scutellum large, set into pronotal sinuation, basal ½ level with pronotum, transversely impressed through middle, without circular depressions, apical ½ level with clavus. Hemelytra opaque, punctate, thickly pubescent, radial vein clearly delimited to cuneal fracture, cuneus much broader than long, posterior fracture before membrane deeply incised, membrane very finely pubescent, margins ciliate, veins linear, indistinct. Venter dark, shining, abdomen strongly pubescent; scent gland



Figs. 1–2. *Dolostethus pubescens.* 1, Male habitus. 2, Metasternal scent gland.

canal curved forward along rim of metapleura (Fig. 2) to anterior margin; legs slender, pale, weakly spined, hind tibiae (of male, at least) distinctly bowed. Genital paramere sickle-shaped, curved to the left and dorsad around genital tergite.

Type-species.—Dolostethus pubescens, new species.

Discussion.—Dolostethus keys to *Cardiastethus* Fieber in Herring (1976) but may be separated by its broader form, proportionately larger eyes and narrow vertex (which is much narrower than diameter of an eye), the abruptly emarginate posterior margin of the pronotum and the distinctive scent gland canal. It resembles and could easily be mistaken for a member of the Isometopinae. However, the presence of a 3-segmented rostrum, a single genital paramere and the absence of closed cells on the membrane will distinguish it from that mirid subfamily.

Dolostethus pubescens Henry and Herring, new species
Fig. 1–2

Male.—Length 1.76 mm, width 1.00 mm, suboval, generally shiny, dark brown, densely clothed with erect and suberect, pale pubescence. Head: Length 0.28 mm, width across eyes 0.52 mm, ocelli 0.14 mm apart (measured from middle of each) width of vertex 0.12 mm, dorsal width of eye 0.20 mm; eyes dark brown, granulate, finely pubescent; ocelli red, set near posterior margin of head; basal carina rounded, distinct. Rostrum: Length 0.42 mm, testaceous, basal segment reddish, apex not surpassing mesocoxae or middle of sternum. Antennae: Length of segments I-IV, 0.10: 0.28: 0.18: 0.18 mm; testaceous, in part infuscated, thickly clothed with long, erect setae, III and IV only slightly thinner than I and II; IV fusiform. Pronotum: Length 0.26 mm, width at base 0.80 mm, shiny dark brown, posterior angles more testaceous; subquadrate, strongly punctate, lateral margins weakly rounded, distinctly carinate, base deeply emarginate, humeral angles bearing blunt indistinct nodes, calli smooth, slightly raised, transversely rugose between, mesoscutum not visible. Scutellum: Length 0.40 mm, width at base 0.52 mm; dark brown, shiny, basal ½ finely punctate, anterior ½ level with pronotum, transversely impressed through middle, impression without circular depressions often found in cardiastethines. Hemelytra: Dark brown, punctate, densely clothed with short, erect, pale setae, radial vein clearly delimited to cuneal fracture, cuneus much broader than long, with pronounced incision at junction with membrane; membrane brownish, paler along margins, only outer and inner veins evident. Venter: Dark brown, pleura shining, sternum and abdomen more fuscous; metapleural scent gland curved forward along outer margin to apex of metapleura (Fig. 2); abdomen clothed with pale, short to long hairs. Legs: Testaceous, sparsely pubescent, coxae distinctly reddish, hind tibiae distinctly curved on basal ½, tibial spines weakly formed, tarsi 3-segmented. Paramere: Slender, sickle shaped.

Holotype.—♂, Azupiza [River] to Miriatiriani [River], Cam. del Pichis [Dept. of Pasco], Peru, July 9, 1920, W. T. Forbes and J. C. Bradley colls., Cornell University Expedition, Lot 607, Sublot 132 (Cornell University Type Collection).

Acknowledgments

We kindly thank Dr. L. L. Pechuman, Cornell University, for the loan of the unique specimen of *Dolostethus pubescens.* We also give thanks to Dr. A. G. Wheeler, Jr., Pennsylvania Department of Agriculture, for discovering this new anthocorid and for his helpful review of the manuscript.

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(TJH) Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania 17120; and (JLH) Systematic Entomology Laboratory, Fed. Res., Sci. and Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

PROC. ENTOMOL. SOC. WASH.
80(4), 1978, pp. 524–537

A NEW GENUS NEAR *CANACEOIDES* CRESSON, THREE NEW SPECIES AND NOTES ON THEIR CLASSIFICATION (DIPTERA: CANACIDAE)

Wayne N. Mathis and Willis W. Wirth

Abstract.—A diagnosis is given of *Paracanace*, new genus, and a key is presented for the separation of the seven known species, including three new species which are described and illustrated: *hoguei*, a new species from Cocos Island, Costa Rica; *lebam*, a new species from Jamaica; and *aicen*, a new species from Dominica. A cladogram is diagrammed for the genus and gives apotypic character states for the phylogeny of the species of *Paracanace* and of its sister-group, *Canaceoides* Cresson.

Surf or beach flies were last reviewed as a family by Wirth (1951). In that publication, Wirth described *Canace maritima* as a new species from the Galapagos Islands. Five years later, Wirth (1956) described two additional species, *C. blantoni* (Panama) and *C. oliveirai* (Brazil); both are closely related to *C. maritima*. In 1969(b), Wirth described a fourth related species, *C. cavagnaroi*, which like *C. maritima* is also from the Galapagos Islands. The present paper is a continuation of this series. The species noted above plus three new ones are distinguished as a new genus, *Paracanace*. A key to the species of *Paracanace* and illustrations of the new species are provided for their identification. Illustrations of the epandrium and surstylus of the male terminalia accompanied the descriptions of each previously described species; neither the descriptions nor the illustrations are republished here.

Paracanace Mathis and Wirth, new genus

Type-species.—*Paracanace hoguei* Mathis and Wirth, new species, by present designation.

Species included.—*Paracanace aicen*, new species; *P. blantoni* (Wirth), new combination; *P. cavagnaroi* (Wirth), new combination; *P. hoguei*, new species; *P. lebam*, new species; *P. maritima* (Wirth), new combination; *P. oliveirai* (Wirth); new combination.

Diagnosis.—*Paracanace* is distinguished from other genera of the family by the following combination of characters (an asterisk indicates apotypic character states): General coloration light to dark gray; head in lateral aspect higher than wide; 3 pairs of eclinate fronto-orbital setae; *2 pairs of proclinate interfrontal setae, posterior pair aligned with, or posterior of median ocellus; mesofrons mostly dull, pollinose; eye in lateral aspect as high as wide, with oblique orientation to general plane of body; 4 pairs of genal setae, anterior pair cruciate anteriorly, 3 posterior pairs dorsally-curved; *anterior notopleural seta reduced, inconspicuous; front femur lacking row of anteroventral, spinelike setae; *middle femur of male with posteroventral row of closely set setae, proximal ones frequently pale; *scutellum bare except for 2 pairs of lateral setae; female cerci with 2 pairs of stout apical setae.

Description.—Small to moderately small beach flies, length 1.43 to 2.57 mm; coloration mostly gray; vestiture mostly pollinose, dull in appearance.

Head: Lateral aspect higher than wide; mesofrons mostly full, pollinose, but specimens of some species with some lustrous, semimetallic reflections as viewed from some angles; mesofrons triangular, nearly equilateral, anterior angle napiform; ocelli arranged to form isosceles triangle, distance between posterior ocelli larger than between either posterior ocellus and median 1; parafrons somewhat membranous and distinguished in color and conformation from mesofrons; fronto-orbits evenly wide along dorsal and anterodorsal margin of eye, continuing ventrally as parafacies. Chaetotaxy of frons as follows: Ocellar bristles large, divergent, inserted between posterior and median ocelli; 2 pairs of proclinate interfrontal bristles, posterior pair more or less aligned with ocellar bristles; 1 pair of proclinate to divergent postocellar bristles inserted posteromedially of posterior ocelli; mesofrons with several other smaller setae, especially anterolaterally; 3 pairs of larger eclinate fronto-orbital bristles and several smaller setae; parafrons with 3–4 smaller setae; inner and outer vertical bristles well developed, inserted posteriad of posterior ocelli. Antenna dark colored, brownish black to black; 3rd segment subcircular with pubescent vestiture; arista slightly longer than combined length of first 3 segments, micropectinate on dorsal and ventral surfaces. Face silvery gray to charcoal gray, bare, broadly carinate medially, ventral margin concave. Gena nearly concolorous with face, slightly darker, about ½ as high as eye anteriorly, becoming higher posteriorly; 4 pairs of genal bristles, anterior pair convergent anteriorly, next 3 pairs dorsally curved; postgena with several pale setae toward ventral margin. Eye in lateral aspect as high as wide, broadly oval to subrectangular, oriented at oblique angle to remainder of head. Clypeus broad, protruding through ventral facial concavity. Maxillary palpus somewhat pale, sparsely setose with fine pale setae.

Thorax: Mesonotum darker than pleural areas, dark brownish gray to charcoal gray, pleural areas uniformly gray. Chaetotaxy of thorax as follows: Acrostichal setae mostly small, hairlike except for 1 pair of larger prescutellar bristles; 4 pairs of dorsocentral bristles, posterior pair displaced laterally; 1 pair of humeral bristles; 1 pair of presutural bristles; often with 1 or 2 pairs of moderately large posthumeral setae; 1 pair of supra-alar bristles; 1 pair of postalar bristles; scutellum bare except for 2 pairs of lateral bristles; mesonotum with several scattered smaller setae in addition to larger bristles; 2 pairs of notopleural bristles, seta at anterior angle much smaller than posterior setae, 1–2 other smaller setae; mesopleuron with 3–4 bristles and several smaller setae, larger bristles inserted on posterior ½; 1 larger ventrally-curved lower mesopleural seta; sternopleuron with 1 larger bristle toward posterodorsal angle and several moderately larger setae anteroventrally; mesopleuron and hypopleuron bare; front and middle coxae setose, several setae pale. Legs generally concolorous with pleural areas, basitarsi of middle and hind leg frequently pale; legs setose, development of setae varying with species. Halter pale. Wing slightly infuscated to mostly hyaline; vein R_1 long; see figures for details.

Abdomen: Mostly concolorous with thoracic pleural areas; symmetrically setose bilaterally; males with 6 terga and epandrium exposed; females with 8 terga and genital cerci exposed. Surstylus of male terminalia simple, digitiform to lobelike except for *P. maritima*, in *P. maritima* with subbasal anterior setulose lobe and constriction. Eighth tergum of female with 1–2 pairs of larger setae; female genital cerci with 2 pairs of apical stout spines; female atrium oval.

Geographic distribution.—The composite distribution of the genus is Neotropical, between 19° north latitude and 23° south latitude. Five of the seven species are known only from islands in the Caribbean Sea and Pacific Ocean.

Key to Species of *Paracanace*

1. Costal vein between humeral crossvein and subcostal break with a row of long, spinelike setae, setal length equal to, or greater than width of 1st costal cell; middle femur of male with posteroventral row of closely set setae along entire length, those along proximal ¼ pale; front femur with 3–4 long setae along posteroventral margin, setal length subequal to 2× femoral width 2
– Setae along anterior margin of wing much shorter, not more than ½ width of 1st costal cell; middle femur of male with posteroventral row of closely set setae along distal ½ only; front femur lacking 3–4 setae as described above 4
2. Three dorsally-curved genal setae subequal in length; body strongly setose (Cocos Island, Costa Rica) *P. hoguei*, new species

- Middle dorsally-curved genal seta about ½ length of setae on either side; body moderately setose 3

3\. Surstylus broader on distal ½, especially evident in lateral view; ventral surstylar margin broadly truncate in lateral and posterior views; posterior margin of surstylus bearing distinct row of longer setae (Jamaica) *P. lebam*, new species

- Surstylus in lateral view swollen along anterior margin near middle, tapering ventrally to broadly rounded ventral margin; posterior margin of surstylus lacking distinct row of longer setae; posteroventral angle of surstylus noticeably produced apically (Dominica) *P. aicen*, new species

4\. Front and middle femora of male with row of about 20 long white setae along proximal ½ of posteroventral margin; surstylus with subbasal anterior setose lobe and constriction before apical enlargement (Galapagos Islands) *P. maritima* (Wirth)

- Front and middle femora of male with not more than 10 long white setae along posteroventral margin at base; surstylus simple, lacking anterior setose lobe or subbasal constriction 5

5\. Tarsi mostly dark, concolorous with tibiae (Galapagos Islands) *P. cavagnaroi* (Wirth)

- Tarsi mostly pale, yellowish, especially basitarsus of hind leg 6

6\. Surstylus slender, angulate, length about 3× width (Brazil) *P. oliveirai* (Wirth)

- Surstylus broad, truncate ventrally, length not more than 2× width, posteroventral angle slightly produced (Panama) *P. blantoni* (Wirth)

Paracanace hoguei Mathis and Wirth, new species

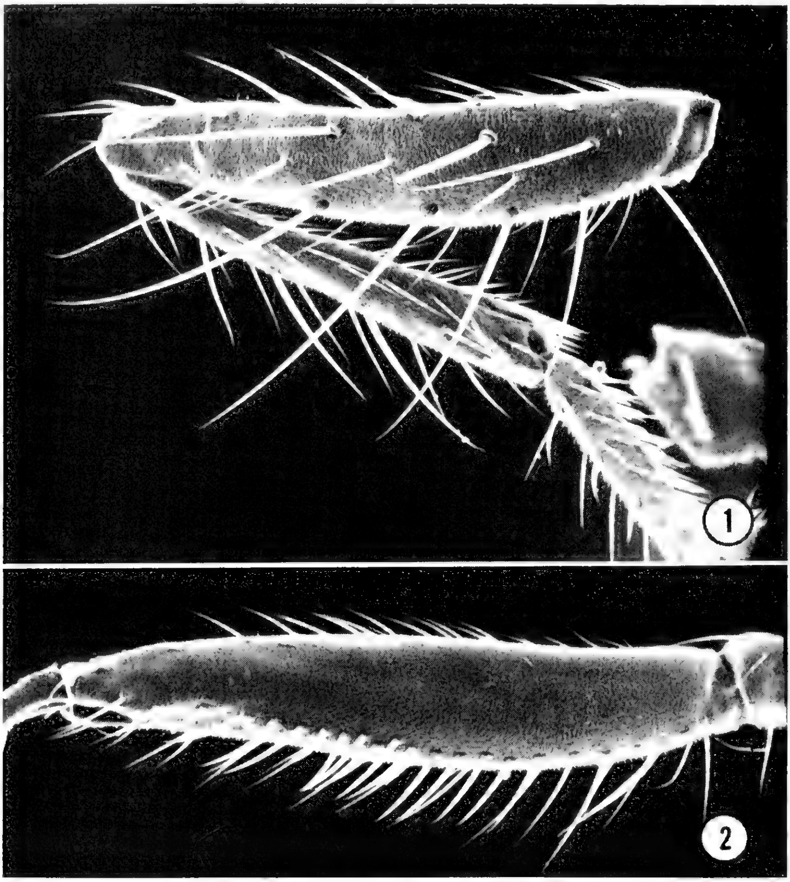
Figs. 1–5

Diagnosis.—Specimens of this species closely resemble those of *P. aicen* and *P. lebam* but are distinguished by the following combination of characters: Middle dorsally-curved genal seta subequal in length to setae on either side; spinelike setae along costal margin larger, those between humeral crossvein and subcostal break longer than width of 1st costal cell; body more setose; surstylus of male terminalia long and slender, digitiform, ventral margin rounded in lateral view, pointed medially in caudal view.

Description.—As in generic description but with the following additional details. Length 1.68 to 2.57 mm.

Head: Mesofrons yellowish gold to faintly lavender, appearing semilustrous from some angles; parafrons yellowish gold to rusty orange; middle dorsally-curved genal bristle subequal in length to setae on either side.

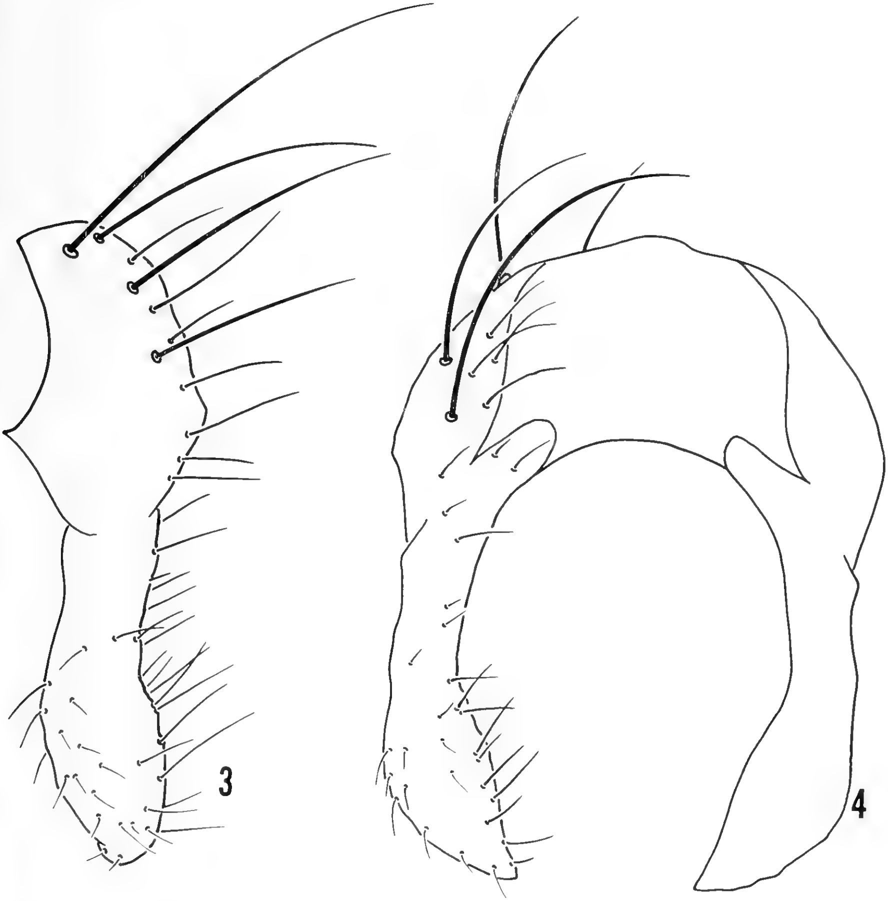
Thorax: Mesonotum charcoal gray. Front femur with 3–4 long setae



Figs. 1–2. *Canace hoguei.* 1, Left front leg, posterior view. 2, Femur of middle leg, posterior view.

along posteroventral margin, length more than 2× greatest width of femur (Fig. 1), front femur also with 5–7 slender pale setae along proximal ½ of ventral surface; middle femur of male with row of closely set setae along posteroventral margin extending to base, setae on proximal ¼ or less pale (Fig. 2); middle and hind basitarsi yellowish brown to grayish brown, front basitarsus paler than tibia but not distinctly yellowish. Wing length averaging 1.91 mm; setae along costal margin spinelike, those between humeral crossvein and subcostal break longer than width of 1st costal cell (Fig. 5).

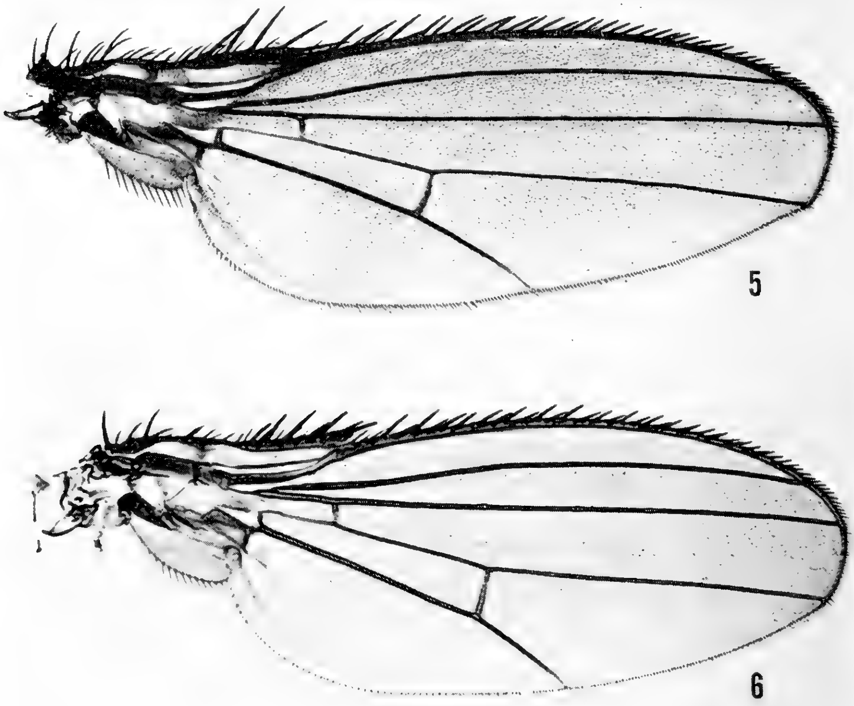
Abdomen: Surstylus of male terminalia (Figs. 3–4) long and slender, slightly angulate in lateral view; ventral margin rounded in lateral view;



Figs. 3–4. *Canace hoguei.* 3, Epandrium and surstylus, lateral view. 4, Same, caudal view.

ventromedial angle pointed in caudal view; posterior margin lacking an isolated row of distinctive setae.

Types.—Holotype ♂, labelled: "COCOS ISLAND (Costa Rica) Wafer Bay 17–22 Apr. '75 C. L. Hogue." Allotype ♀ and 170 paratypes (34 ♂, 136 ♀) with same label data as the holotype. The holotype, allotype, and most of the paratypes will be deposited in the Los Angeles County Museum of Natural History. Paratypes will also be deposited in the National Museum of Natural History, Washington, D.C., the British Museum (Natural History), London, and the California Academy of Sciences, San Francisco.



Figs. 5–6. Wing. 5, *Canace hoguei.* 6, *Canace aicen.*

Geographic distribution.—This species is known only from the type-locality, Isla del Coco (Cocos Island). This island is situated approximately 550 km from the Costa Rican coast in the Pacific Ocean 5°33′ north latitude; 87° west longitude).

Etymology.—The species epithet *hoguei* is a genitive patronym honoring the distinguished entomologist Dr. C. L. Hogue, collector of the type-series.

Paracanace lebam Mathis and Wirth, new species
Figs. 7–9

Diagnosis.—Specimens of *P. lebam* are similar and closely related to those of *P. aicen* and *P. hoguei* but are distinguished by the following combination of characters: Middle dorsally-curved genal seta about ½ length of setae on either side; spinelike setae along costal margin, particularly those between humeral crossvein and subcostal break, about as long as width of 1st costal cell; general appearance setose, like specimens of *P.*

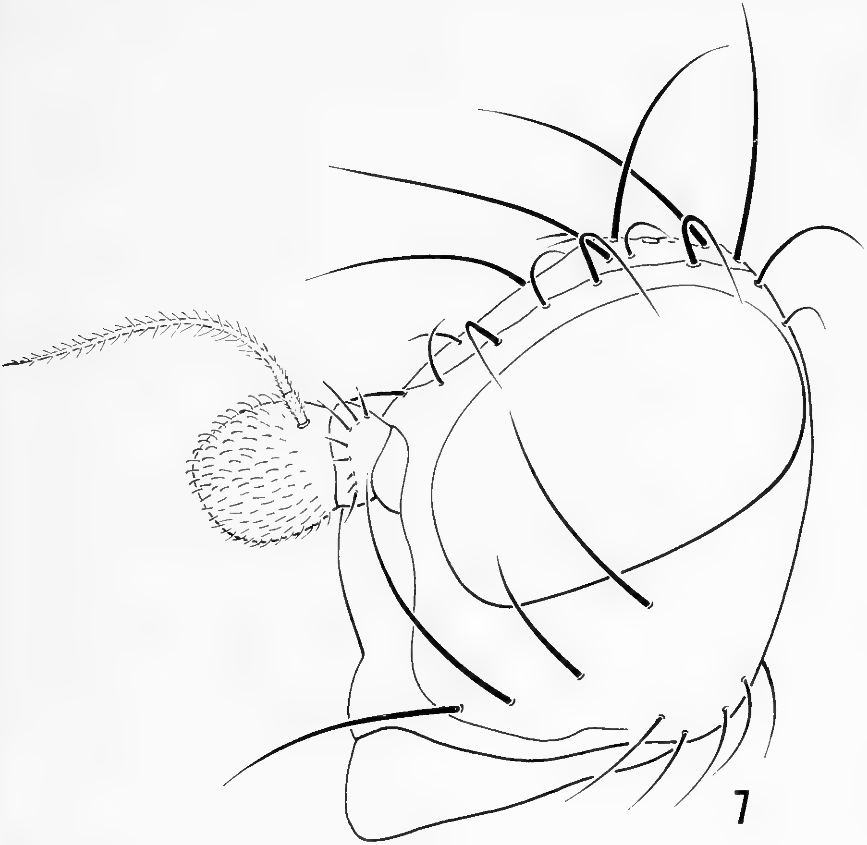


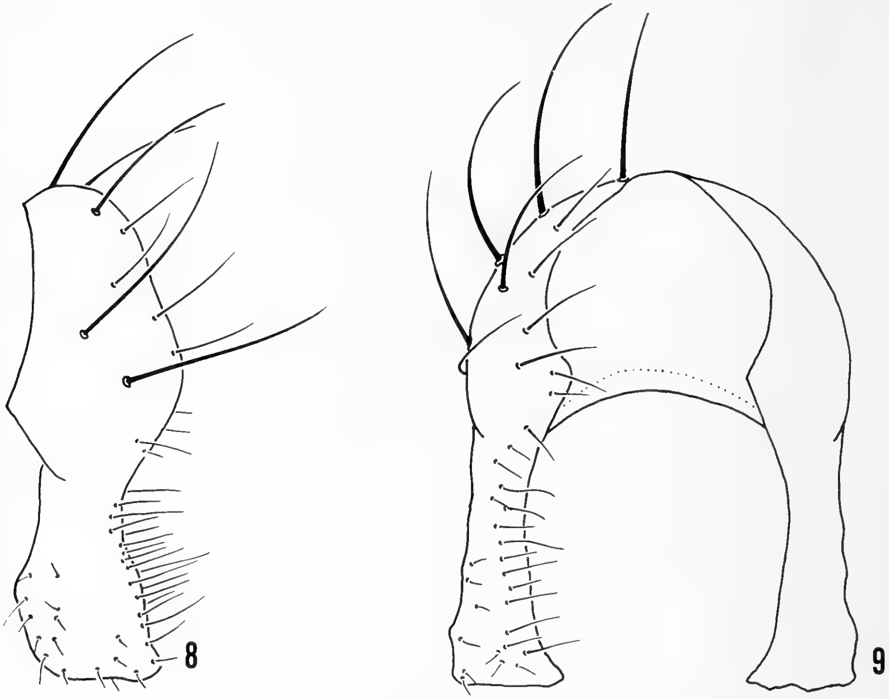
Fig. 7. *Canace lebam*, head, lateral view.

aicen; surstylus of male terminalia about 1½× as long as wide in lateral view, broadly truncate along ventral margin in lateral and caudal views; ventromedial angle pointed in caudal view; posterior margin with distinctive row of longer setae.

Description.—As in generic description but with the following additional details. Length 1.76 to 1.94 mm.

Head (Fig. 7): Mesofrons dark, grayish brown to black, dull, only slightly darker than general coloration of mesonotum; parafrons grayish olivaceous to brownish green, contrasting distinctly with darker mesofrons; middle dorsally-curved genal seta about ½ length of setae on either side.

Thorax: Mesonotum grayish brown to charcoal gray. Front femur with 3–4 long setae along posteroventral margin, length more than 2× greatest width of femur, front femur also with 2–3 slender pale setae along proximal



Figs. 8–9. *Canace lebam.* 8, Epandrium and surstylus, lateral view. 9, Same, caudal view.

⅓ of ventral surface; middle femur of male with row of closely set setae along posteroventral margin extending nearly to base, setae on proximal ¼ or less pale; basitarsi of all legs nearly concolorous, grayish brown, only slightly paler than tibia. Wing length averaging 1.65 mm; setae along costal margin spinelike, those between humeral crossvein and subcostal break equal in length to width of 1st costal cell.

Abdomen: Surstylus of male terminalia (Figs. 8–9) about 1½× as long as broad, in lateral view; ventral margin broadly truncate in lateral and caudal views; ventromedial angle of surstylus in caudal view somewhat pointed; posterior margin with distinctive row of setae.

Types.—Holotype ♂, labelled: "JAMAICA Runaway Bay Feb. 1969 W. W. Wirth bay shore." Allotype ♀ and 1 ♂ paratype with same label data as the holotype. The type-series is in the National Museum of Natural History, Washington, D.C., type number 75303.

Geographic distribution.—Specimens of *P. lebam* have been collected only at the type-locality, Runaway Bay, Jamaica.

Etymology.—The species epithet *lebam* is an anagram of the proper name Mabel (Wirth), after whom this species is named. The epithet is a noun in apposition to the generic name.

Paracanace aicen Mathis and Wirth, new species
Figs. 6, 10–11

Diagnosis.—*Paracanace aicen* is closely related and similar to *P. lebam* and *P. hoguei* but is distinguished from either of the latter by the following combination of characters: Middle dorsally-curved genal seta about ½ length of setae on either side; spinelike setae along costal margin about as long as width of 1st costal cell; general appearance setose but less so than in *P. hoguei*; surstylus of male terminalia with anterior swelling near middle in lateral view and broadly rounded ventrally; in caudal view with developed ventromedial angle but not pointed; posterior margin of surstylus not notably setose.

Description.—As in generic description but with the following additional details. Length 1.72–2.24 mm.

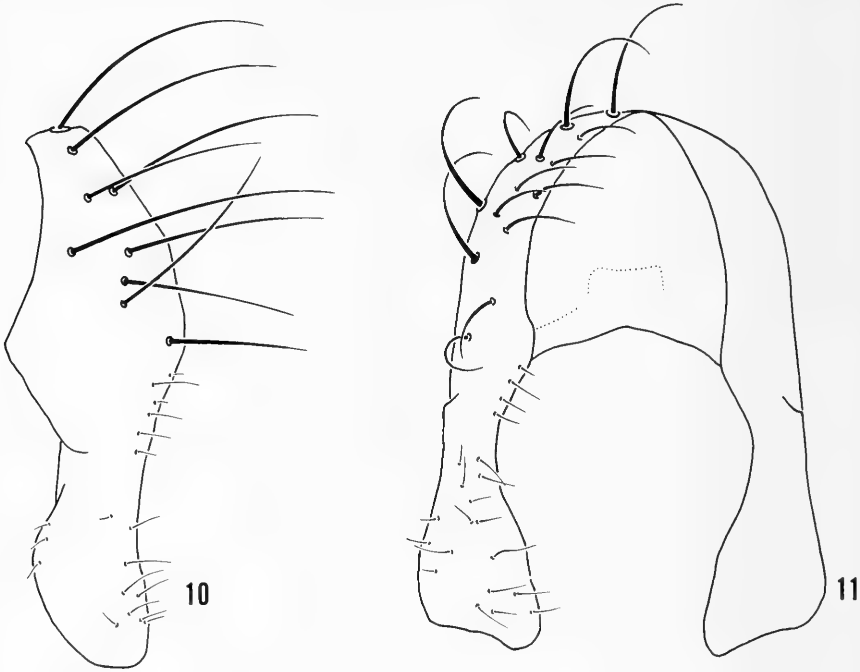
Head: Mesofrons dark, grayish brown to black, dull, nearly concolorous with mesonotum; parafrons yellowish to olivaceous brown, contrasting distinctly with darker mesofrons; middle dorsally-curved genal seta about ½ length of setae on either side.

Thorax: Mesonotum dark grayish brown. Front femur with 3–4 long setae along posteroventral margin, length more than 2× greatest width of femur, front femur also with 5–7 slender pale setae along proximal ½ of ventral surface; middle femur of male with row of closely set setae along posteroventral margin extending nearly to base, setae on proximal ¼ or less pale; basitarsi of all legs nearly concolorous with tibiae. Wing length averaging 1.76 mm; setae along costal margin spinelike, those between humeral crossvein and subcostal break equal in length to width of 1st costal cell (Fig. 6).

Abdomen: Surstylus of male terminalia (Figs. 10–11) about 2× as long as broad; anterior margin swollen near middle in lateral view; ventral margin broadly rounded in lateral view; ventromedial angle of surstylus produced but not pointed in caudal view; posterior margin lacking obvious row of setae.

Types.—Holotype ♂, labelled: "DOMINICA, W. I. Calibishie 27 Feb. 1965 W. W. Wirth sea shore/Bredin-Archbold Smithsonian Bio. Surv. Dominica." Allotype ♀ and 3 paratypes (1♂, 2♀) with same label data as the holotype. The type-series is in the National Museum of Natural History, Washington, D.C., type number 75304.

Geographic distribution.—Specimens of *P. aicen* have been collected only from the type-locality, Calibishie, Dominica.



Figs. 10–11. *Canace aicen.* 10, Epandrium and surstylus, lateral view. 11, Same, caudal view.

Natural history.—Wirth collected the type-series on an algae covered, intertidal rock shelf on the beach to the west of the village.

Etymology.—The species epithet *aicen* is an anagram of the proper name Necia (Dianne Mathis), after whom this species is named. The epithet is a noun in apposition to the generic name.

General Discussion

Paracanace belongs to a group of related taxa of the family Canacidae that is recognized as follows: Body coloration generally gray; head in lateral aspect narrow, higher than wide; 3 pairs of larger eclinate fronto-orbital setae; frons short; eye as high as wide, suboval to subrectangular, and oriented at an oblique to nearly vertical angle to general plane of head; 1 distinct, ventrally-curved lower mesopleural seta. Although the relationships among the included taxa of this assemblage have not been adequately clarified, several taxa can be grouped into closely related, monophyletic groups as evidenced by apotypic character states. Among these taxa are the genera *Canaceoides* Cresson (Wirth, 1969) and *Paracanace*. We believe

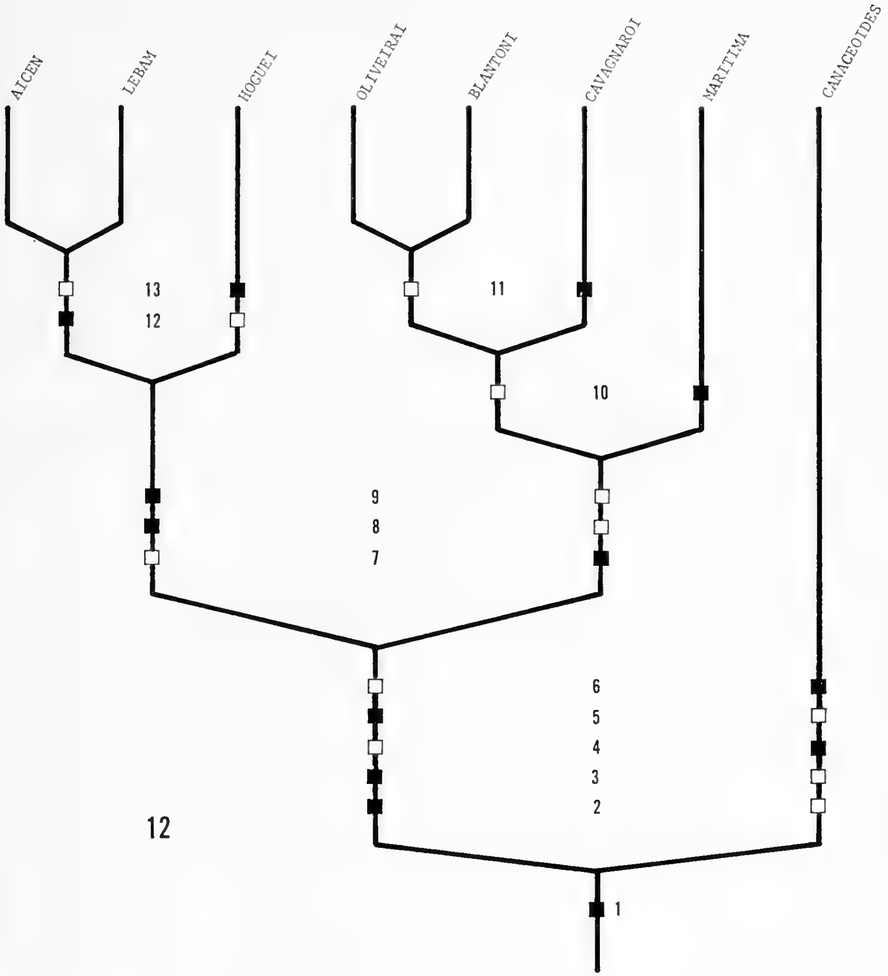


Fig. 12. Argumentation scheme for the hypothetical phylogeny of the genus *Paracanace*. Filled squares indicate apotypic character states; open squares indicate plesiotypic character states.

that these two genera are sister-groups. This relationship is corroborated by the reduced anterior notopleural seta, a character state we interpret to be apotypic.

We suggest that the phylogeny of the species of *Paracanace* is as diagrammed in Fig. 12. Numbers in the cladogram correspond with characters listed in Table 1. The relative plesiotypic-apotypic states were determined primarily from out-group comparisons.

Table 1. Characters and character states used in cladistic analysis of the species of *Paracanace.*

CHARACTER	CHARACTER STATE	
	Apotypic	Plesiotypic
1. Anterior notopleural seta	reduced, less than ½ length of posterior seta	subequal to posterior seta
2. Disc of scutellum	bare	with seta
3. Number of large interfrontal setae	2 pairs	1 pair
4. Setae on 8th tergum of female	setae subequal	with 1 or 2 pairs of larger setae
5. Setae along posteroventral margin of middle femur of male	partial to complete row of closely set setae	lacking row of closely set setae
6. Shape of female atrium	U-shaped, incomplete posterior end	oval
7. 3–4 long slender black setae along posteroventral margin of front femur	absent	present
8. Setae along costal margin of wing	large, spinelike	normally developed
9. Row of setae along posteroventral margin of middle femur of male	extending along entire length	evident only along distal half
10. Male terminalia, shape of surstylus	complicated with subbasal constriction and anterior subbasal setose lobe	simple, fingerlike
11. Color of basitarsus	dark	pale
12. Length of middle dorsally-curved genal seta	short, about ½ length of setae on either side	long, subequal to length of setae on either side
13. Coloration of mesofrons	semilustrous, faintly lavender	dull, dark greenish to grayish brown or black

The monophyly of *Paracanace* is clearly evident, being confirmed by three apotypic character states as noted in the diagnosis and Table 1. We suggest that the genus differentiated into two lineages. The first lineage includes the three new species described above. These three species are closely related as evidenced by the large spinelike setae along the costal wing margin and the nearly complete row of closely set setae along the posteroventral margin of the middle femur. The two West Indian species, *P. aicen* and *P. lebam*, of this lineage are distinguished from *P. hoguei* by the short middle dorsally-curved genal seta and the dull coloration of the mesofrons.

The second lineage of the genus comprises the remaining four species, *P. blantoni, P. cavagnaroi, P. maritima* and *P. oliveirai.* These species are characterized by the loss of the three or four long slender black setae along the posteroventral margin of the front femur. Of this group, *P. maritima* is characterized by the unique conformation of the male terminalia and the 20 or so long white hairs on the front femur. This distinctive species probably arose from a lineage apart from the other three species as indicated on the cladogram. The remaining three species are all quite similar in general appearance; and, except for specimens of *P. cavagnaroi*, reference to structures of the male terminalia will usually be necessary to accurately identify them. Unlike the other two species, the tarsi of specimens of *P. cavagnaroi* are dark.

Acknowledgments

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(WNM) Department of Entomology, NHB 169, Smithsonian Institution, Washington, D.C. 20560; and (WWW) Systematic Entomology Laboratory, Fed. Res., Sci. and Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

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80(4), 1978, pp. 538–542

SANDFLY DISTRIBUTION IN THE UNITED STATES, WITH A FIRST RECORD FOR COLORADO (DIPTERA: PSYCHODIDAE)

R. B. Eads

Abstract.—The 11 species and subspecies of *Lutzomyia* known to occur in the United States are listed, with their known distribution and host preferences. *Lutzomyia oppidana* (Dampf) is recorded in Colorado for the first time.

The isolation of three strains of a new *Phlebotomus* fever group virus from the grey woodrat, *Neotoma micropus*, in Cameron County, Texas, in December 1973 and March 1974, (Calisher et al., 1977) has focused attention upon the species and distribution of sandflies in the United States and their possible role in virus transmission. The International Catalogue of Arboviruses (Berge, 1975) lists 20 serologically related viruses in the *Phlebotomus* fever group, 13 of which have been recovered from phlebotomine flies. The new virus, called Rio Grande, was not recovered from hematophagous insects (principally mosquitoes), including several hundred *Lutzomyia* spp., tested by this laboratory during the 1971 outbreak of Venezuelan equine encephalitis (VEE) in south Texas and during the next two years (Vector-Borne Diseases Division (VBDD) unpublished data).

VBDD personnel collected three species of *Lutzomyia—texana* (Dampf), *cruciata* (Coquillett) (=diabolica) and *anthophora* (Addis)—in CDC light traps on the same ranch in Cameron County, Texas, during 1971–73, from which the Rio Grande virus isolations were made. The most likely candidate for *Neotoma* to *Neotoma* transmission of Rio Grande virus is *L. anthophora*, since it is known to feed on rabitts and rodents (Addis, 1945), and it uses woodrat nests as diurnal resting sites (Young, 1972). *Lutzomyia cruciata* feeds readily on rodents in the laboratory. The only thing known of its feeding habits in south Texas is that in localized areas it is annoying to human beings. Addis (1945) reported that this species entered homes in Uvalde, Texas, and bit people during the summer of 1944. We encountered a similar situation at Del Rio, Texas, in 1964. *Lutzomyia texana* feeding habits are not known, but it is considered likely that reptiles are the usual hosts.

The fact that New World sandflies reach greatest specific diversity and population density in the tropics has, perhaps, kept to a minimum the interest displayed in these insects in temperate to cold zones. However,

Table 1. *Lutzomyia* recorded in the United States.

Species	Distribution	Authority	Hosts	Authority
L. aquilonia (Fairchild and Harwood, 1961)	Alberta, Washington	Fairchild and Harwood, 1961; Harwood, 1965	Probably reptiles	—
L. anthophora (Addis, 1945)	Texas, Mexico	Addis, 1945; Vargas and Najera, 1953; Easton et al., 1968	Rabbits, rodents No records biting man	Addis, 1945
L. californica (Fairchild and Hertig, 1957)	California, Texas, Washington	Fairchild and Hertig, 1957; Fairchild and Harwood, 1961; Easton et al., 1967	Reptiles	Chaniotis, 1967
L. cruciata (Coquillett, 1907) (= *P. diabolicus*)	Texas, Mexico, Central America	Hall, 1936; Eads, et al., 1965; Addis, 1945; Easton et al., 1967	Mammals, bites man	Hall, 1936; Addis, 1945; Christensen and Herrer, 1973
L. oppidana Dampf, 1944)	Mexico, Colorado, Montana, Texas, Washington, British Columbia	Vargas and Najera, 1953; Fairchild and Harwood, 1961; Chaniotis, 1974	Reptiles	Harwood, 1965

Table 1. *Continued.*

Species	Distribution	Authority	Hosts	Authority
L. shannoni (Dyar, 1929)	Louisiana to N. Carolina and Florida, Mexico south to Argentina	Stone et al., 1965; Rosabel and Miller, 1970	Mammals, bites man	Rosabel and Miller, 1970; Christensen and Herrer, 1973
L. stewarti (Mangabeira and Galindo, 1944)	California, Mexico	Mangabeira and Galindo, 1944; Vargas and Najera, 1953	Reptiles	Chaniotis, 1967
L. texana (Dampf, 1938)	Texas, Mexico	Eads et al., 1965; Vargas and Najera, 1953; Easton et al., 1967	Probably reptiles	—
L. vexatrix occidentis (Fairchild and Hertig, 1957)	California, Montana, Washington, Texas, Mexico, Alberta	Fairchild and Hertig, 1957; Fairchild and Hertig, 1959; Chaniotis, 1974	Reptiles	Chaniotis, 1967
L. vexatrix vexatrix (Coquillett, 1907)	Louisiana, Maryland, Connecticut, Ontario	Stone et al., 1965; Rosabel and Miller, 1970; Aitken et al., 1977	Reptiles	Fairchild and Harwood, 1961; Shannon, 1913; Rosabel and Miller, 1970
L. cubensis (Fairchild and Trapido, 1950)	Cuba, Florida (Big Pine Key)	Fairchild and Trapido, 1950; Young, 1972	Unknown	—

the growing number of reports of sandfly recoveries in the United States and southern Canada suggests that the comparatively small number of species present are widely distributed (Fairchild and Harwood, 1961; Harwood, 1965; Eads et al., 1965; Easton et al., 1967; Easton et al., 1968; Downes, 1972; Chaniotis, 1974; and Aitken et al., 1977).

The 11 species and subspecies of *Lutzomyia* recorded from the United States are listed in Table 1, with their known distribution and host preferences. Selected authorities for these data are included. A key to the *Lutzomyia* species known to inhabit the United States has been provided by Rosabal and Miller (1970).

Only two of the tropical, man-biting species of *Lutzomyia* seem sufficiently adaptable to diverse climatic conditions to extend their distribution into the United States. *Lutzomyia cruciata* has been reported from Central America, Mexico and Texas. *Lutzomyia shannoni* (Dyar) is even more widely distributed, having been taken from Argentina to Louisiana, North Carolina and Florida. *Lutzomyia anthrophora* is the only other species recorded from the United States known to feed on mammals.

The species collected in the more northern latitudes of the United States are known or suspected to feed on coldblooded vertebrates. Ground squirrel and other rodent burrows are used for larval and pupal development (Chaniotis, 1967).

We have recently collected a female (7/19/77) and a male and female (7/23/77) *L. oppidana* in Larimer County, Colorado, in CDC light traps. To our knowledge, those were the first *Lutzomyia* recovered in the state. The CDC light traps were operated some 200 trap nights in Larimer County during June–September 1977, in conjunction with extensive western encephalitis investigations. Our small catch indicates low population densities of this sandfly—or that the CDC traps are not attractive to these insects. Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) burrows were common around both trapping sites from which *L. oppidana* were taken.

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PROC. ENTOMOL. SOC. WASH.
80(4), 1978, pp. 543–547

DESCRIPTION OF A NEW *POLYMERUS*, WITH NOTES ON TWO OTHER LITTLE KNOWN MIRIDS FROM THE NEW JERSEY PINE-BARRENS (HEMIPTERA: MIRIDAE)[1]

Thomas J. Henry

Abstract.—The new species, *Polymerus rostratus*, is described from the New Jersey Pine-Barrens. *Hudsonia ericoides* L. is shown to be the true host of *Parthenicus vaccini* Van Duzee and *Polymerus rostratus*, and *Arenaria caroliniana* Walt. the host of *Polymerus nigropallidus* Knight.

Several interesting species of Miridae have been described from pine-barren habitats along the eastern coast of the United States. Knight (1923), and in other papers, described from the New Jersey Pine-Barrens several mirids, most of which have not been recorded since. The hosts of these bugs have been confused or, in most cases, have remained unknown.

On a recent collecting trip to the New Jersey Barrens, my colleague, A. G. Wheeler, Jr., and I discovered the hosts of several species known only from one or a few localities and one new species. The description of a new *Polymerus* and notes on two other mirids are presented here.

Polymerus rostratus Henry, new species

Figs. 1–3

Male holotype.—Length 3.60 mm, width 1.36 mm, generally brown, with the head and pronotum largely black; clothed with silvery, silky or tomentose pubescence, intermixed with simple, semierect setae. Head: Length 0.40 mm, width 0.82 mm, black, basal carina, part of lorum and median line to base of tylus brownish yellow; vertex 0.30 mm, dorsal width of eye 0.26 mm; vertex and part of front set with a few silvery, silky setae. Rostrum: Length 1.98 mm, reaching well beyond hind coxae to 6th abdominal segment, segments I and II pale, III dark brown, IV black. Antennae: I, length 0.36 mm, black, extreme base pale; II, length 1.40 mm, dark brown or reddish brown, base black, thickly clothed with fine, brown, recumbent setae; III, length 0.76 mm, reddish brown; IV, length 0.56 mm, reddish brown. Pronotum: Length 0.72 mm, width at base 1.24 mm, largely black, with the basal ½, collar and median line lighter brown (some specimens are entirely black, except for the basal margin and narrow median line); surface weakly rugose, calli slightly raised; calli and area immediately behind thickly clothed with silvery, silky pubescence; scutellum pale brown, basal angles black (some specimens are more nearly black with only the apical 3rd brown), thickly set with silky pubescence. Hemelytra: Largely brown, with the clavus darker brown, its margins and inside ½ often approaching black, the costal and radial veins fuscous, often tinged with red, apical ⅓ of embolium and apex of corium red, cuneus bright red with the apex and outer margin pale; clothed with silvery, silky pubescence. Membrane: Translucent grayish brown, anal area more black, veins pale brown. Venter: Pale yellow, dorsal ½ of pleura black, abdomen greenish yellow with a black line across pleural region, genital segments more testaceous; thoracic segments thickly set with silvery, silky pubescence, abdomen clothed with longer, simple setae. Legs: Testaceous to yellowish orange, front and middle femora with 2 subapical red bands, the basal band often fading into broad reddish area, hind femora with 3 reddish bands, these often becoming infuscated, the basal 1 often broadly faded; tibiae testaceous, tinged with red, spines black, these sometimes with indistinct black spots at base; tarsi testaceous, 3rd segment and claws black. Genitalia: Parameres typical of genus, not distinguishable from other *Polymerus*; spiculum of aedeagus slender, apex acutely produced, covered with microspines.

Allotype female.—Length 3.72 mm, width 1.64 mm; very similar to male in coloration and markings, differing largely in the broader form and more brown pronotum. Head: length 0.44 mm, width 0.90 mm, black, median line, basal carina and spot on either side of vertex pale; vertex 0.42 mm, dorsal width of eye 0.24 mm. Rostrum: Length 2.20 mm, reaching beyond base of ovipositor to 7th abdominal segment. Antennae: I, length 0.34 mm, black, extreme base and apex pale; II, length 1.28 mm, brown, base black; III, length 0.78 mm, reddish brown; IV, length 0.50 mm, reddish brown. Pronotum: Length 0.84 mm, width at base 1.36 mm, largely brown, calli and anterior angles black; scutellum pale yellowish, black across basal angles. Hemelytra: more brown, less fuscous and red than males.

Type-data.—Holotype: ♂, Burlington Co., N.J., near Tabernacle, June 13, 1977, taken on *Hudsonia ericoides*, T. J. Henry and A. G. Wheeler, Jr. coll. (USNM type no. 75743). Allotype: ♀, same data as holotype (USNM). Paratypes: 1 ♂, 9 ♀, same data as holotype; 15 ♂, 11 ♀, Ocean Co., N.J., Rt. 37 near Lakehurst, 14 June 1977, taken on *H. ericoides*, T.J.H. and A.G.W. coll. (Am. Mus. Nat. Hist., Pa. Dept. Agric., Pa. State Univ., USNM); 1 ♀, Ocean Co., N.J., near Tom's River along Rt. 37, 14 June 1977, taken on *H. ericoides*, T.J.H. and A.G.W. coll. (Pa. Dept. Agric.).

Remarks.—Polymerus rostratus is very similar in coloration and markings to *Polymerus basalis* Reuter, 1876. When first collected, this species was thought to be *basalis*; but after some field observation, its smaller size and quicker, more erratic flight habit strongly suggested a new form.

Polymerus rostratus keys to *basalis* in Blatchley (1926) and Knight (1923

Fig. 1. Typical New Jersey Pine-Barrens habitat for *Arenaria caroliniana* and *Hudsonia ericoides*. Fig. 2. *Hudsonia ericoides*. Fig. 3. *Arenaria caroliniana*.

and 1941). It is easily separated from *basalis* by its smaller size (♂, N = 10, $\bar{x}$ = 3.75, 3.48–4.04; ♀, N = 10, $\bar{x}$ = 3.91, 3.68–4.32), mostly black head, longer rostrum that reaches well beyond the hind coxae to the 6th or 7th abdominal segment, the relative lengths of the antennal segments (*rostratus*, segment II 2× length of segment III vs. *basalis*, segment II nearly 4× length of segment III) and the male genitalia.

Extensive collecting throughout much of the Pine-Barrens region revealed that golden heather, *Hudsonia ericoides* L. (Cistaceae) (Figs. 1 and 2) is the only host of *rostratus*. Only several miles away, but outside the undisturbed Barrens, 13 examples of *basalis* were found breeding on ox-eye daisy, *Chrysanthemum leucanthemum* L., in an old field along Rt. 37 near Tom's River, June 14, 1977.

Polymerus nigropallidus Knight

Polymerus nigropallidus (Knight, 1923), one of our prettiest *Polymerus* species, is known only from Brown's Mills Junction, New Jersey. Concentrated collecting in the Pine-Barrens disclosed that this species is actually very common and breeds on the low growing, pine-barren sandwort, *Arenaria caroliniana* Walt. (Caryophyllaceae) (Figs. 1 and 3). Numerous adults and a few nymphs were taken June 13 and 14, 1977 at Lakehurst, Ocean Co. and Tabernacle, Burlington Co.

Parthenicus vaccini Van Duzee

Parthenicus vaccini (Van Duzee, 1915) is known only from Long Island, N.Y., Massachusetts and Florida (Knight, 1923). The name *vaccini* would suggest that this species breeds on *Vaccinium* spp. and, in fact, numerous authors have carried this misnomer through the literature. A special effort was made to collect *vaccini* on cranberry and blueberry, but only after carefully beating plants of *Hudsonia ericoides* did we discover both adults and nymphs. *Parthenicus vaccini* was common wherever *Hudsonia ericoides* was growing. Eight males, 1 macropterous female and 21 brachypterous females were taken near Tabernacle, June 13; 1 male and 11 brachypterous females were taken along Rt. 37 near Tom's River, June 13; and 1 male and 4 brachypterous females were taken at Lakehurst, June 14.

Acknowledgments

I wish to give special thanks to Dr. K. C. Kim (Pa. State Univ.) for supporting this project and to Drs. Kim and A. G. Wheeler, Jr. (Pa. Dept. Agric.) for reading the manuscript and making useful comments.

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The Frost Entomological Museum, Department of Entomology, The Pennsylvania State University, University Park, Pennsylvania 16802 (mailing address: Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania 17120).

Footnote

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80(4), 1978, pp. 548–552

DESCRIPTION OF THE MALE OF *NEUROBEZZIA GRANULOSA* (WIRTH) (DIPTERA: CERATOPOGONIDAE)

William L. Grogan, Jr. and Willis W. Wirth

Abstract.—The male of *Neurobezzia granulosa* (Wirth) is described and illustrated for the first time. Locality records are presented. The genus is compared with its nearest relative, *Neurohelea* Kieffer.

Wirth and Ratanaworabhan (1972) proposed the genus *Neurobezzia* for *Bezzia granulosa* Wirth (1952) from California and indicated its relationship to *Neurohelea* Kieffer in the predaceous midge tribe Heteromyiini. The genus *Neurobezzia* has been known only from the female sex of *granulosa*; in this paper we provide the first description and illustrations of the male. For an explanation of special terminology of Ceratopogonidae see Wirth (1952); terms dealing with male genitalia are those of Snodgrass (1957).

Neurobezzia probably evolved from an ancestor most similar to *Neurohelea*. We believe that these two genera are plesiotypic in comparison with other genera in the tribe Heteromyiini and that they are probably annectant types similar to ancestral heteromyiines. This is plausible in view of the fact that they lack elongated hind 4th tarsomeres, elongated hind claws, bifid 4th tarsomeres, or spinose fore femora, apotypic characters present in other genera in this tribe. Wirth et al. (1974) included these two genera in their key to the Ceratopogonidae. They may be further differentiated by the following characters:

Neurobezzia	*Neurohelea*
Wing with 1 radial cell	Wing with 2 radial cells
Hind claws without basal inner teeth	Hind claws with basal inner teeth
Antennal ratio 0.89–0.94	Antennal ratio 1.28–1.33
Claspettes narrowly separated basally	Claspettes broadly separated basally

Neurobezzia granulosa (Wirth)
Fig. 1

Bezzia granulosa Wirth, 1952:240 (female; California).

Neurobezzia granulosa (Wirth); Wirth and Ratanaworabhan, 1972:244 (combination; fig. female flagellum, wing, mandible, palpus, legs, claws, genitalia).

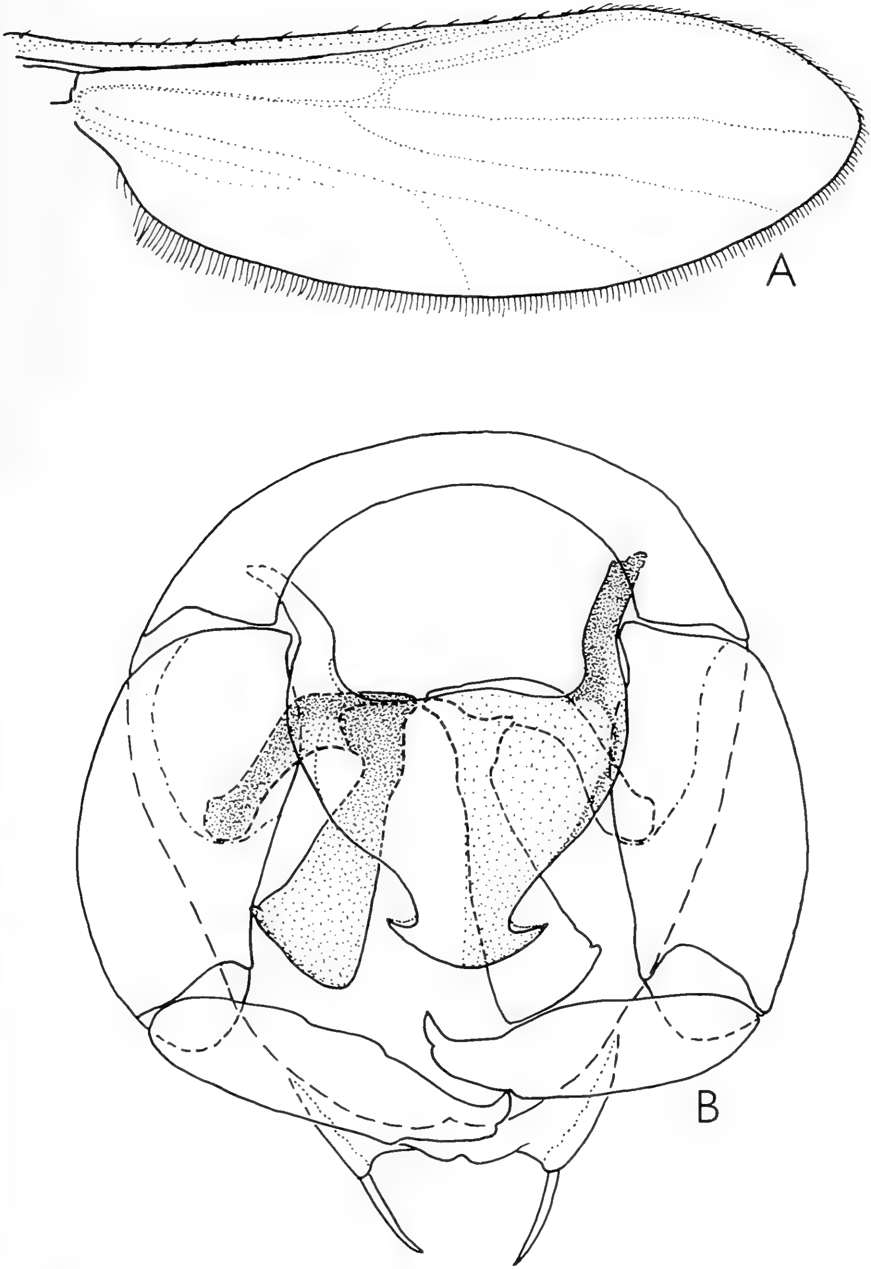

Fig. 1. *Neurobezzia granulosa*, male. A, Wing. B, Genitalia.

Female.—For a detailed description of the female see Wirth (1952) and Wirth and Ratanaworabhan (1972). To these descriptions may be added the following: Wing length 1.85 mm; breadth 0.68–0.74 mm; costal ratio 0.91–0.93; vein M2 complete, forking at r-m crossvein as described by Wirth (1952), not obsolescent at base as figured by Wirth and Ratanaworabhan (1972). Antennal flagellomeres with lengths in proportion of 23-15-15-15-15-16-18-19-23-23-24-23-28; palpal ratio 2.59–2.67. Claws of fore and mid legs with basal inner teeth; hind claws without basal inner teeth.

Male.—Wing length 0.94–1.00 mm; breadth 0.35 mm.

Head: Dark brown. Eyes narrowly separated. Antennal pedicel darker brown; flagellum brown; proximal 10 flagellomeres ovoid, distal 3 flagellomeres elongate; plume moderately well developed. Palpus light brown, relatively short, extending just beyond tip of proboscis.

Thorax: Brown. Legs lighter brown; 4th tarsomeres cordiform; 5th tarsomeres slightly swollen; claws small, equal, without basal inner claws, tips bifid. Wing (Fig. 1A) hyaline, more slender than in female; anterior veins pale gray, just slightly darker than posterior veins; radial cell extending to 0.66 of wing length, costa extending beyond to 0.95 of wing length and bearing a sparse fringe; media forking just proximad of r-m crossvein, mediocubital fork slightly beyond r-m crossvein. Halter brown.

Abdomen: Brown; intersegmental areas pale; pleuron granular purple. Genitalia as in Fig. 1B. Ninth sternum 3.3× broader than long, base curved with a broad deep caudomedian excavation, ventral membrane spiculate; 9th tergum tapering slightly distally to a broad rounded tip with a subapical row of 7 large setae, cerci short, each bearing a single large stout seta. Basimere curved, 2.25× longer than broad; telomere nearly straight, covered with dense fine pubescence, tip curved and pointed. Aedeagus about as long as broad, membrane and ventral surface spiculate, basal arch broad, reaching to 0.35 of total length; basal arm long, slightly recurved, very heavily sclerotized; distal portion more lightly sclerotized, tapering slightly distally on proximal ⅔ then abruptly on distal ⅓ to a rounded tip; underlying membrane broadly crescent-shaped and extending beyond tip of aedeagus. Claspettes narrowly separated; distal portion heavily sclerotized, expanded distally into broad paddle shaped structures; basal arm more heavily sclerotized, recurved nearly 180°, tip slightly bulbous.

Distribution.—California and Oregon; locality records plotted in Fig. 2.

New records.—CALIFORNIA: *Tulare Co.*, Elderwood, 14 May 1976, W. D. Murray, 2 ♂. OREGON: *Deschutes Co.*, Sparks Lake, 24 July 1969, K. Goeden, light trap, 1 ♀.

Discussion.—Our presumption that the Tulare County males are

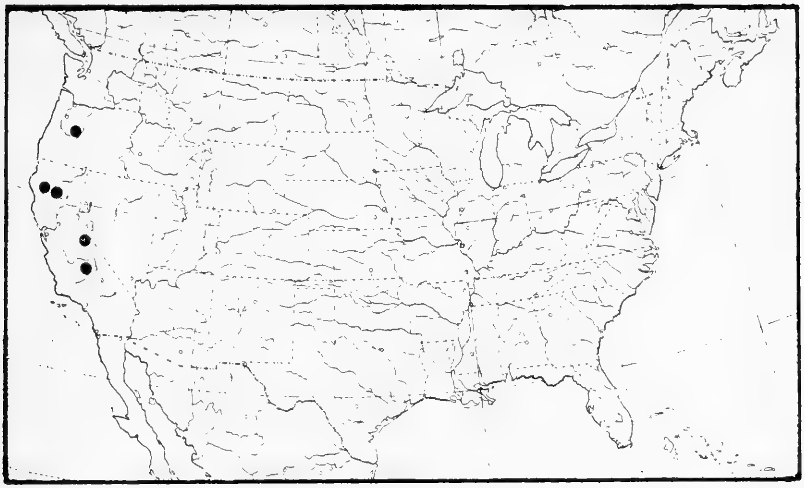

Fig. 2. Locality records for *Neurobezzia granulosa.*

Neurobezzia granulosa is based on a careful comparison with the male characters of other genera of Heteromyiini, and the elimination of those whose males differ markedly, or which are not known to occur in the western United States. We are troubled by the fact that the males have legs without distinct paler markings, while the females of *N. granulsoa* have bicolored legs. However the leg color varies somewhat in our females, and sexual dimorphism in leg color is common in known species of Heteromyiini. The position of the base of vein M2, arising at the r-m crossvein in the female, and arising slightly proximad in the male also forms a discrepancy which possibly can be explained by the usual sexual dimorphism in wing venation common in this tribe.

Acknowledgments

We are grateful to Ethel L. Grogan for preparing the illustrations. Thanks are due W. D. Murray of the Delta Mosquito Abatement District in Visalia, California, for submission of the lot of ceratopogonid specimens in which the males were discovered.

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(WLG) Department of Entomology, University of Maryland, College Park, Maryland 20742 (now at: Department of Biological Sciences, Salisbury State College, Salisbury, Maryland 21801); and (WWW) Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. and Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

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80(4), 1978, pp. 553–555

A NEW SPECIES OF *HYLEMYA* FROM WYOMING (DIPTERA: ANTHOMYIIDAE)

George C. Steyskal

Abstract.—The new species, *Hylemya* (*Delia*) *evansi*, is described from Teton County, Wyoming.

Specimens submitted for determination were collected by Howard E. Evans during behavioral studies on solitary wasps. An undescribed species was included and is described at this time to make its name available.

Hylemya (*Delia*) *evansi* Steyskal, new species

Figs. 1–4

Male.—Very similar to *H. angustitarsis* Malloch, to which it will run in the keys of Huckett (1965, 1971) and Hennig (1966–1976). It is also similar to *H. antiqua* (Meigen), the alternate to *H. angustitarsis* in Huckett's (1971:191) key; but the male terminalia differ in more ways from *H. evansi* than do those of *H. angustitarsis. Hylemya tenuiventris* (Zetterstedt), the alternate to *H. angustitarsis* in Hennig's key (1966–1976:703), is also similar to *H. evansi.* Both *H. angustiventris* and *H. tenuiventris* have the 5th sternum of the male abdomen with narrower and more elongate lobes than those of *H. evansi,* and both also lack the 3 contiguous blunt apical setae on each lobe. *Hylemya gracilipes* Malloch and *H. curvipes* Malloch also bear considerable resemblance to *H. evansi*; but both of these species, among other differences, have only one, much longer, blunt apical seta on each 5th sternal lobe. The most diagnostic characters seem to be those of the 5th sternum, the curved hindfemur and the short anterodorsal setae on hindtibia.

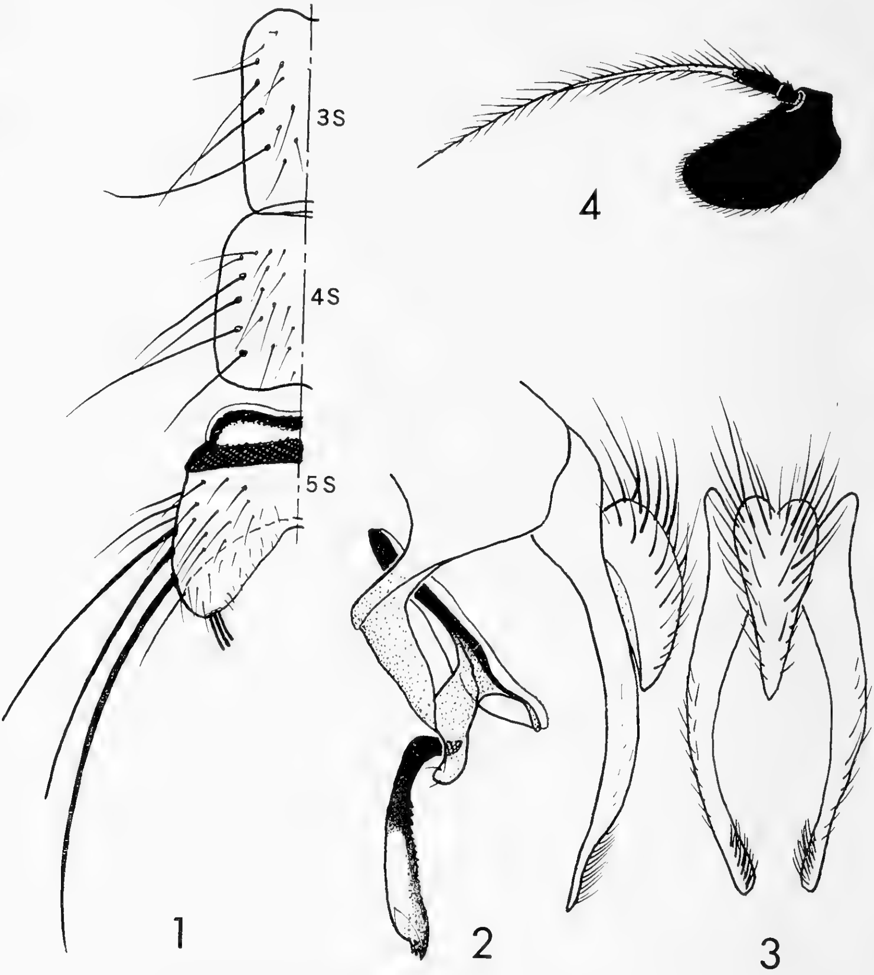
The following characters will distinguish *H. evansi* from its nearest relatives:

Antenna as in Fig. 4; 3rd segment with short pubescence, 1.8× as long as wide; aristal hairs 2× as long as basal diameter of arista.

Thorax dull, ochreous gray; notopleural area without fine setae; pre-alar seta present, shorter than posterior notopleural seta.

Wing 4.4 to 4.5 mm long; tinged with yellowish; setulae lacking on underside of costa beyond humeral crossvein.

Legs black, base of tibiae sometimes a little piceous; hindfemur bowed upward, lower margin concave in profile; tarsi simple. Forefemur with only minute setulae posteriorly besides macrochaetae; foretibia with blunt posteroventral apical seta hardly longer than apical tibial diameter. Mid-



Figs. 1–4. *Hylemya* (*Delia*) *evansi, male.* 1, Abdominal sterna 3 to 5, right half. 2, Postabdomen, left profile. 3, Terminalia, rear view. 4, Antenna.

femur with 3 or 4 posteroventral setae in basal ⅓; midtibia without distinct non-apical erect setae; midtarsus with neither elongate dorsal basitarsal setae nor elongate nor enlarged apical segmental setae. Hindfemur with 2 or 3 conspicuous ventral setae near apex and about 4 or 5 moderately long ventral setae basad of midlength; hindtibia without erect ventral setae, but with 4 or 5 anterodorsal setae not longer than tibial diameter and 3 posterodorsal setae, the subbasal one little more than ½ as long as the other 2.

Abdominal sterna 3 to 5 as in Fig. 1, sternum 3 slightly longer than sternum 4. Fifth sternum with short stout processes (lobes) bearing 3 closely adjacent, blunt-tipped, apical spinules; 3 long and a few short lateral setae; and no setae on mesal margin.

Postabdomen as in Figs. 2 and 3; mesolobus (fused cerci) from posterior view (Fig. 2) slightly concave laterally and nearly evenly tapering; surstyli well separated, bowed outwards, their depressed apices bearing backwardly extending fringe; distiphallus with strong posterior (ventral) spicules, most evident in profile in medial ⅓, but present to apex, where a few are also lateral.

Female unknown.

Holotype and 5 paratypes, males, Wyoming: 14 mi E Moran Postoffice, Teton County (just E of Grand Teton National Park), 29 July 1977, notebook no. 2549 (H. E. Evans), USNM Type #75716 in United States National Museum of Natural History.

I am happy to name the species for my friend, the well-known hymenopterist Howard E. Evans; the epithet is a noun in the genitive case.

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Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. and Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

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80(4), 1978, pp. 556–574

NEW SPECIES, RECORDS AND KEY TO TEXAS LIPOSCELIDAE (PSOCOPTERA)

Edward L. Mockford

Abstract.—Three new species of *Liposcelis* and one of *Belaphotroctes* are described from Texas: *Liposcelis hirsutoides*, *L. ornatus*, *L. pallidus* and *Belaphotroctes alleni*. New state records and additional distribution records of eight other species are included as well as a key to the 13 species of Liposcelidae now recorded from Texas.

The family Liposcelidae contains small psocids from 1–2 mm in body length, usually of somewhat flattened form with broad hind femora. Many of the species commonly invade houses and stored foods; these are called booklice. They have been incriminated along with dust mites as probable causative agents of asthmatic reactions (Spieksma and Smits, 1975). Some of the Liposcelids that occur in rangeland grasses are thought to be intermediate hosts of the fringed tapeworm of sheep (Allen, 1973).

Mockford and Gurney (1956) reviewed the psocids of Texas but did not include the Liposcelidae. Sommerman (1957) described three new species of *Liposcelis* from Texas, and Mockford (1963) described a new species of *Belaphotroctes* from that state. To date, these are the only published records of Liposcelidae from Texas. The present paper includes descriptions of three new species of *Liposcelis*, *L. hirsutoides*, *L. ornatus* and *L. pallidus*, and one new species of *Belaphotroctes*, *B. alleni*. Three species of *Liposcelis*, one of *Belaphotroctes* and one of *Embidopsocus* are recorded from Texas for the first time. These are *Liposcelis bostrychophilus* Badonnel, *L. knullei* Broadhead, *L. liparus* Broadhead, *Belaphotroctes badonneli* Mockford and *Embidopsocus* sp. Thus, the Texas liposcelid fauna is raised from 4 to 13 species. Records constituting important range extensions are included for *Belaphotroctes hermosus* Mockford, *Liposcelis deltachi* Sommerman and *L. nasus* Sommerman. A key to the species is included. Collecting for liposcelids in Texas has as yet been very scanty, and it is likely that additional collecting will produce more species.

Measurements were made on slide-mounted material with a filar micrometer. The micrometer unit = 0.462 μ. Abbreviations used in the measurements and descriptions are explained as follows: Mx4 = distal segment of maxillary palpus and its length (Table 1); H = greatest head width; f_1, f_2, f_3 = first, second and third flagellomeres and their lengths (Table 1); F + Tr = length of posterior femur + trochanter; FW = greatest

Table 1. Measurements (in μ) of Texas species of Liposcelidae. Abbreviations explained in text.

Name and Catalog Number	Mx4	H	f_1	f_2	f_3	F + tr	Fw	T
Belaphotroctes alleni ♀, ELM #2118	100	312	66	55	52	294	141	262
B. alleni ♀, ELM #2552	99	298	63	57	53	284	137	244
Liposcelis hirsutoides ♀, ELM #1673	84	282	53	53	52	284	160	222
L. hirsutoides ♀, ELM #1674	80	276	54	53	51	288	164	212
L. hirsutoides ♀, ELM #1674	89	292	48	54	60	288	179	216
L. hirsutoides ♀, ELM #4617	84	296	60	68	71	284	179	218
L. ornatus ♀, ELM #4617	78	264	63	—	—	274	170	200
L. ornatus ♀ ELM #4617	78	256	59	86	—	264	168	198
L. pallidus ♀, ELM #2117	—	326	108	161	187	386	208	280

Name and Catalog Number	t_1	t_2	t_3	SI	SII	MdIX	Se
Belaphotroctes alleni ♀, ELM #2118	55	38	49	60	—	139	114
B. alleni ♀, ELM #2552	54	35	48	58	—	134	138
Liposcelis hirsutoides ♀, ELM #1673	88	34	48	48	52	78	62
L. hirsutoides ♀, ELM #1674	88	37	49	43	45	80	73
L. hirsutoides ♀, ELM #1674	89	36	50	44	46	80	76
L. hirsutoides ♀, ELM #4617	87	33	43	44	46	82	—
L. ornatus ♀, ELM #4617	89	33	46	46	46	80	67
L. ornatus ♀, ELM #4617	84	36	50	40	42	77	69
L. pallidus ♀, ELM #2117	141	41	53	65	—	120	97

width of posterior femur; T = length of posterior tibia; t_1, t_2, t_3 = lengths of first, second and third posterior tarsomeres; SI = longest lateral seta of pronotum and its length (Table 1); SII = longest anterolateral marginal seta of mesonotum and its length (Table 1); MdIX = a specific long abdominal seta (Fig. 21) (nomenclature of Badonnel, 1962) and its length (Table 1); Se = longest seta of epiproct and its length (Table 1); Tg_1–Tg_{11} = abdominal terga 1–11.

The taxonomic categories of section, group and subgroup used in *Liposcelis* follow Badonnel (1962, 1963).

In the distribution records, the author was collector unless otherwise indicated. Catalogue numbers referred to in Table 1 are included with the records.

Subfamily Embidopsocinae

Embidopsocus sp.

The single specimen is a nymph and cannot be determined to species.

Record.—Texas: Cameron County: Southmost Palm Grove near Brownsville, 27 January 1958, beating branches of thorny trees, 1 nymph.

Belaphotroctes alleni Mockford, new species

Diagnosis.—Similar to *B. simberloffi* Mockford and *B. hermosus*, differing from both in having no closely-set group of sense clubs on ventral surface of Mx4 but having instead diffusely-arranged sense clubs in the same area (Fig. 45).

Female.—Measurements as given in Table 1. Morphology: Flagellum with short terminal segment partially fused with subterminal 1. Ocelli absent (only apterous forms known). Two units in each eye. Lacinial tip (Fig. 1) with outer and inner prongs bifid distally; denticle between these relatively broad. Mx4 (Fig. 2) with 3 blunt and 4 pointed sensilla dorsally; ventrally (Fig. 45) with scattered blunt sensilla in distal ½. Antennal sensilla: f_1 with 2 distal rods, 1 stouter than other; f_2 with 1 slender distal rod, f_5 and f_6 each with a stout distal rod; f_8 with a slender, curved distal rod, f_{10} with a stout distal rod, f_{12} with a slender curved distal rod. Pretarsal claw with denticle near tip and short, acuminate appendage near base. Spermapore sclerite (Fig. 3, compare to Fig. 7 of *B. hermosus*) slender, tapering toward opening. Sculpture of integument: Vertex with faint curved depressed lines enclosing (or partially enclosing) areoles; a series of fine vermiculate marks between antennal socket and eye on each side. Abdominal terga without sculpture except for faint transverse lines bordering posterior ends of segments. Chaetotaxy: Vertex with scattered sparse setae showing much variation in length, laterals longer than centrals (a representative lateral = 35 μ, a representative central = 17 μ). Antennal orbit with a short posteromedian (< scape), long median (> scape + pedicel) and short anteromedian (< scape) seta. Pronotum (Fig. 4): Median lobes each with 2 setae near anterior margin; each lateral lobe with long SI and short scattered setae including 1 slightly longer than others near base of median lobe. Meso-metanotum with few, scattered setae. Prosternum (Fig. 5), with 4–5 setae on each lateral margin including an anterior minute 1, followed by a somewhat longer 1, followed just in front of middle by a much longer 1, followed near posterior margin by 1 somewhat shorter than previous 1. Meso-metasternal setae as in Fig. 5. Setae of Tg_{8-11} arranged as in Fig. 6; 1 pair of epiproctal setae much longer than others and curved. Color (in alcohol 14 years): Eye patches black. Well-sclerotized body areas yellowish brown, slightly darker in bands across abdominal terga 1–8.

Holotype ♀ and 3 ♀ paratypes, Texas, Jeff Davis County, Davis Mountains State Park, 25–26 July 1962, sifting ground litter of oak leaves and juniper debris, ELM #2118. The types are in my collection.

Additional record.—New Mexico: Chaves County: Roswell, Diamond A Ranch, 24 November 1959, R. W. Allen collector, 18 ♀, ELM #2552.

Note.—The material on which the description of *B. hermosus* was based contained a mixture of true *hermosus* and this species. Figure 14b in Mockford (1963) refers to this species; all other figures, all measurements and the description except for reference to this figure are based on true *hermosus.*

Etymology.—The species is named for Dr. Rex W. Allen, whose studies have strongly suggested that psocids may be vectors of the fringed tapeworm of sheep, *Thysanosoma actinioides* Diesing. This is one of the psocid species that Allen has used in his studies.

Belaphotroctes badonneli Mockford

Belaphotroctes badonneli Mockford, 1972:115.

This species was described from Alachua County, Florida and was previously known only from that area. The present record marks an extension of the range westward by approximately 750 miles and suggests a range around the northern Gulf Coast.

Record.—Texas: Matagorda County: State Highway 35, 8.3 miles along highway southwest of Old Ocean, 29 November 1975, beating broad-leaved trees, 1 ♀.

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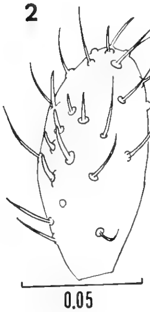

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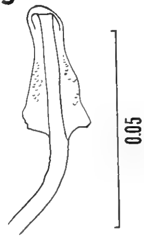

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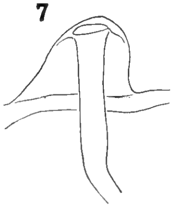

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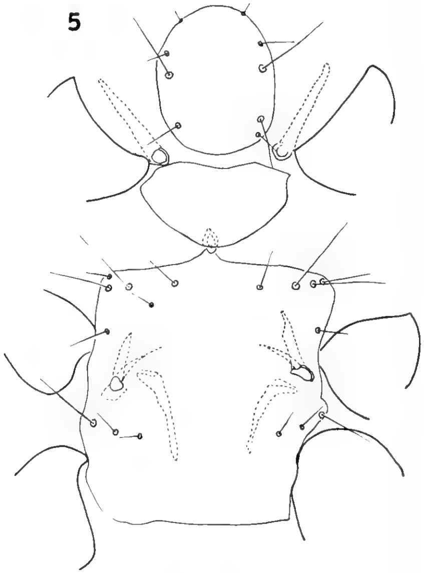

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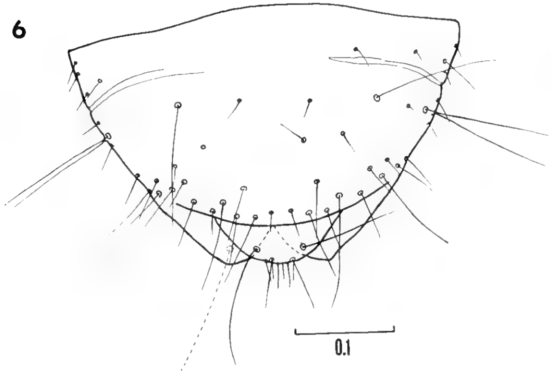

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Belaphotroctes hermosus Mockford

Belaphotroctes hermosus Mockford, 1963:27.

The published records of this species as restricted by the description, above, of *B. alleni* are entirely from the Lower Rio Grande Valley. The following record extends the known range somewhat northward.

Record.—Texas: Brooks County: Laguna Salada, 5 miles southwest of Falfurrias, 5 September 1974, collector not indicated, 1 ♀.

Genus *Liposcelis*

Section I, Group A, Subgroup Aa

Liposcelis liparus Broadhead

Liposcelis liparus Broadhead, 1947:42.

This species has not been recorded previously from the Western Hemisphere but is known from England and South Africa. In addition to the Texas record cited below, I have several records from Arizona and New Mexico, and one from Nebraska.

Record.—Texas: Pecos or Terrell County (about at county line), 42.4 miles along U.S. Highway 90 east of Marathon, 25 July 1962, beating juniper, 1 ♀.

Section I, Group A, Subgroup Ab

Liposcelis deltachi Sommerman

Liposcelis delta-chi, Sommerman, 1957:127.

Published records of this species are only from the type-locality, Garner State Park, Uvalde County, Texas. The following records extend the known range east and west.

Records.—Texas: Jeff Davis County, Davis Mountains State Park, 25–26 July 1962, sifting ground litter, 1 ♀; Kleberg County, Kingsville, 7 October 1972, collector not indicated, 1 ♀; Pecos or Terrell County, 42.4 miles east of Marathon along U.S. Highway 90, 25 July 1962, beating junipers, 1 ♀; same locality and date, beating yucca, F. Hill collector, 1 ♀.

←

Figs. 1–6. *Belaphotroctes alleni.* 1, Lacinial tip, scale of Fig. 3. 2, Distal segment of maxillary palpus (Mx4), dorsal view. 3, Spermapore sclerite. 4, Thoracic terga showing chaetotaxy. 5, Thoracic sterna showing chaetotaxy, scale of Fig. 4. 6, Abdominal segments 8–11 showing dorsal chaetotaxy. 7, *Belaphotroctes hermosus*, spermapore sclerite, scale of Fig. 3. Fig. 8, *Liposcelis hirsutoides*, lacinial tip, scale of Fig. 3. Scales in mm.

Liposcelis hirsutoides Mockford, new species

Diagnosis.—Similar to *L. hirsutus* Badonnel, *L. distinctus* Badonnel and *L. puber* Badonnel. Differing from *L. hirsutus* and *L. puber* in paler coloration, from *L. distinctus* in having short, truncated setae of the *hirsutus* type on all abdominal terga. Also differing from *L. hirsutus* in smaller size and in having SII approximately parallel-sided.

Female.—Measurements as given in Table 1. Morphology: Median suture of vertex recognizable as a break in sculpture, edges of areoles abutting on it appearing scalloped. Eight units in each eye. Lacinial tip with prongs strongly diverging; outer prong slightly indented apically, inner acute apically. Mesothoracic parapsidal sutures visible as thin lines. Tg_1 with 3 transverse sclerotized bands, the anterior 2 interrupted medially. Intersegmental lines 2–3, 3–4, 4–5, 5–6, 6–7 and 7–8 of abdominal terga each marked in middle by a narrow dark band (Fig. 9). Common trunk of gonapophyses (Fig. 19) short and broad. T-shaped sclerite as in Fig. 18. Sculpture: Vertex (Fig. 12) with impressed lines enclosing transverse areoles, most of them bearing tubercles, usually arranged in rows. Abdominal terga (Fig. 13) with rather regularly spaced tubercles, some slightly darker than others, arranged in arcs, vaguely setting out areoles, but tubercles not in areolate pattern in some areas. Weakly sclerotized portions of Tg_{5-7} with sculpture in same pattern but less pronounced. Chaetotaxy: Setae of vertex long (a typical central seta $= 20\ \mu$) and tapering distally but not pointed at tips (Fig. 12), from about as long to about 2× as long as distances between their bases. Pronotum (Fig. 34) with SI decidedly longer than other setae of lateral lobe, slightly widened in its middle; 2 other setae forming anterior row, both slightly widened in their middles; 3 shorter setae posterior to these. Meso-metathorax with SII about same length as SI and almost imperceptibly widened in its middle. Six prosternal setae in an arc; mesosternal row of 9 setae (Fig. 20). Short (a typical seta of $Tg_5 = 10.6\ \mu$) truncated setae abundant on all abdominal terga. Setae of Tg_{8-11} as in Fig. 21. Color (in alcohol 3 months; specimens in alcohol 16 years generally paler): Eye patches black. Head, body and appendages generally medium grayish brown; abdominal terga slightly darker on sides than in middles; head with a slight orange hue. Tg_{1+2}, except anterior 2 sclerotized strips, paler than rest of body. A narrow dark line between each pair of adjacent abdominal terga from 2–8. Each of Tg_{5-7} pale along its entire posterior border.

Male.—The single male on hand is not in suitable condition to allow preparation of a description. The sexes were associated by similarity in color, sculpture of integument and chaetotaxy. There are five units in the eye.

Holotype female.—Texas, Cameron County, State Hwy. 4, 11 miles along

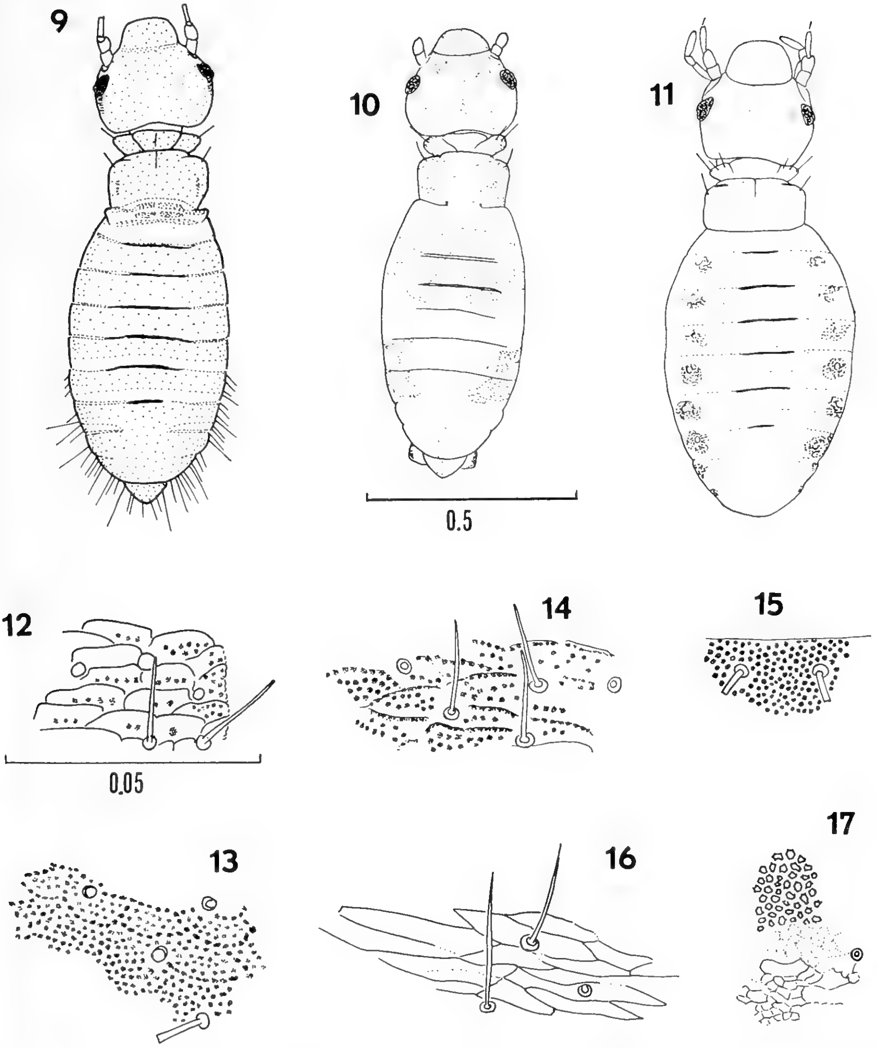
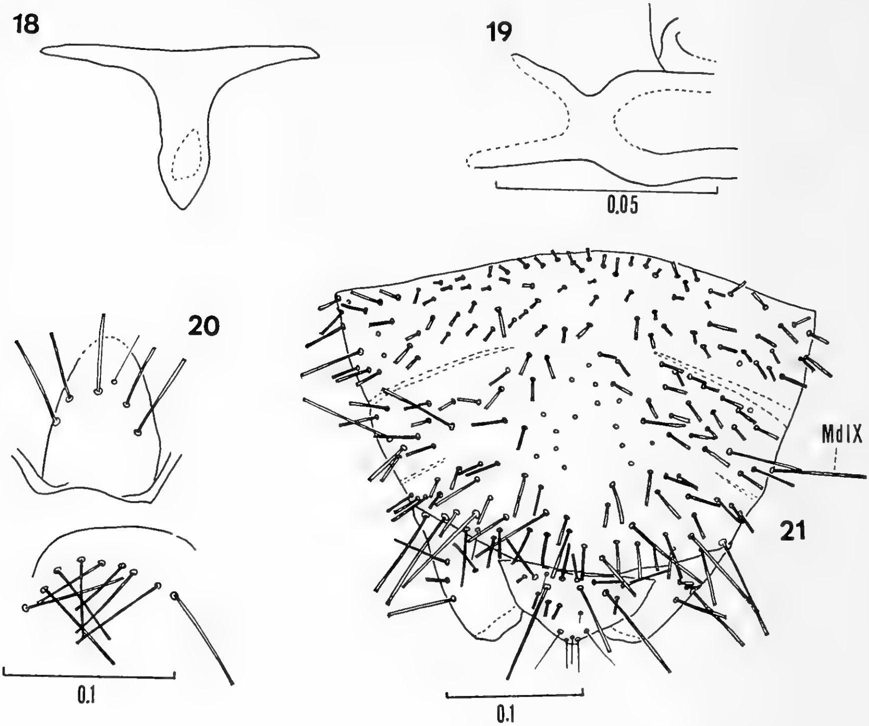


Fig. 9. *Liposcelis hirsutoides* ♀, dorsal view; appendages, except antennal bases, not shown; scale of Fig. 10. Fig. 10, *Liposcelis ornatus* ♀, dorsal view; appendages, except antennal bases, not shown. Fig. 11, *Liposcelis deltachi* ♀, dorsal view; appendages, except antennal bases and maxillary palpi, not shown. Fig. 12, *Liposcelis hirsutoides* ♀, sculpture of vertex bordering median ecdysial line. Fig. 13, *Liposcelis hirsutoides* ♀, sculpture of 4th abdominal tergum near middle. Fig. 14, *Liposcelis ornatus* ♀, sculpture of vertex near median ecdysial line. Fig. 15, *Liposcelis ornatus* ♀, sculpture of 4th abdominal tergum near middle. Fig. 16, *Liposcelis pallidus* ♀, sculpture of vertex in parietal region. Fig. 17, *Liposcelis pallidus* ♀, sculpture of 6th abdominal tergum near middle. Figs. 13–17 to scale of Fig. 12.



Figs. 18–21. *Liposcelis hirsutoides* ♀. 18, T-shaped sclerite, scale of Fig. 19. 19, Common trunk of gonapophyses. 20, Thoracic sterna showing chaetotaxy. 21, Abdominal terga 8–11 showing chaetotaxy.

highway east of junction with Farm Rd. 511, 30 January 1958, beating branches of thorny shrubs on old dune ridge, ELM #1674. Ten ♀ paratypes, 1 nymph, and 1♂ (not designated a paratype due to its poor condition), same data as holotype; 1 ♀ paratype, same data except one mile farther east on same highway. The types are in my collection.

Additional records.—Texas: Jim Wells County, 18 miles north of Alice along U.S. Highway 281, 10 June 1962, beating vegetation, F. Hill and E. L. Mockford collectors, 1 ♀; Matagorda County, State Hwy. 35, 2 miles along highway northeast of Van Vleck, 29 November 1975, beating broad-leaved trees and on tree trunks, 2 ♀, ELM #4617.

Liposcelis nasus Sommerman

Liposcelis nasus Sommerman, 1957:128.

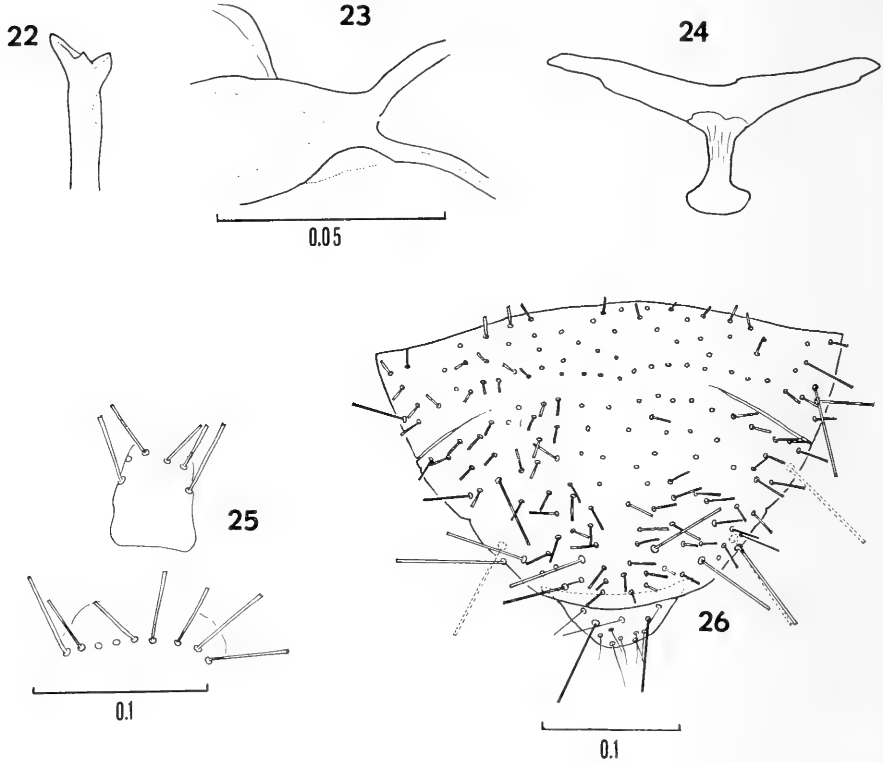
The following record extends the range of this species north of the Lower Rio Grande Valley, the area to which other published records are restricted.

Record.—Texas: Bexar County, San Antonio, Northwest Preserve Park, 29 June 1973, beating dried cut grass and oak litter, 1 ♀.

Liposcelis ornatus Mockford, new species

Diagnosis.—Marked with a striking pattern (Fig. 10) somewhat similar to those of *L. marginepunctatus* Badonnel, *L. nigrofasciatus* Badonnel and *L. fasciatus* Enderlein. Differing from *L. marginepunctatus* in lacking series of lateral spots on each side of abdomen. Differing from *L. nigrofasciatus* and *L. fasciatus* in lacking transverse dark bands of terga in posterior half of abdomen.

Female.—Measurements as given in Table 1. Morphology: Median suture of vertex indicated by slight break in sculpture. Eight units in each eye. Lacinial tip (Fig. 22) normal for the genus. Mesothoracic parapsidal sutures developed as distinct arched lines. Tg_1 apparently uniformly sclerotized. Intersegmental lines 2–3, 3–4, 4–5, 5–6, 6–7 and 7–8 of abdominal terga each marked in middle by a narrow dark band, those of 3–4 and 4–5 more obvious than others (Fig. 10). Common trunk of gonapophyses (Fig. 23) relatively short and broad. T-shaped sclerite as in Fig. 24. Sculpture: Vertex (Fig. 14) with impressed lines partially enclosing transverse areoles, most of them bearing vague tubercles, the tubercles, instead of lines, forming margins of areoles in places. Abdominal terga (Fig. 15) with regularly spaced minute tubercles. Weakly sclerotized portions of Tg_{5-7} with same pattern, somewhat less pronounced. Chaetotaxy: Setae of vertex as described for *L. hirsutoides.* Pronotum (Fig. 32) with SI decidedly longer than other setae of lateral lobe, but other (3) setae of anterior row each at least ⅔ length of SI; 3 short setae posterior to these. Meso-metathorax with SII about same length as SI. Six prosternal setae in row of 4 and 2 more posterior; mesosternal row of 9 setae (Fig. 25). Setae of Tg_{8-11} as in Fig. 26. Color (in alcohol 3 months): Eye patches black. Ground color of head dull ivory, of thorax and abdomen dull ivory to white. Postclypeus grayish brown. A medium brown band along midline of vertex to frontal area, there dividing into 2 arms, each running to antennal base. Antennae grayish brown. Propleura medium brown. A medium brown area covering each side of meso-metanotum and upper parts of corresponding pleura. A brown spot on each side of midline in Tg_1, a broad brown band, somewhat irregular on its lateral edges, covering most of Tg_3 and Tg_4 and extending on each side of midline onto Tg_5. A brown spot surrounding the spiracle on each side of Tg_7 and another pair of such spots on Tg_8. Tg_{9-11} with a slight brownish wash. Antennae pale brown. Legs each with a diffuse brown spot dorsally on the femur; tibiae each with a diffuse brown band near distal end and scattered brown pigment granules more basally. Tarsomeres pale brown, somewhat darker in first than in others.



Figs. 22–26. *Liposcelis ornatus* ♀. 22, Lacinial tip, scale of Fig. 23. 23, Common trunk of gonapophyses. 24, T-shaped sclerite, scale of Fig. 23. 25, Thoracic sterna showing chaetotaxy. 26, Abdominal terga 8–11 showing chaetotaxy.

Male.—Unknown.

Holotype female.—Texas, Matagorda County, State Highway 35, 2 miles along highway northeast of Van Vleck, 29 November 1975, beating broad-leaved trees and on tree trunks. Five ♀ paratypes, same data as for holotype. The types are in my collection.

Additional records: UNITED STATES: Florida: Alachua County, Cross Creek, 15 November 1952, beating red maples along creek, 1 ♀; Gainesville, 16 November 1952, beating palm leaves, 1 ♀; Newnan's Lake, 28 March–11 June 1952, trunks and branches of broad-leaved trees and vines in hammock, 4 ♀, 3 nymphs; Glades County, 8.6 miles south of Brighton on State Highway 781, 18 April 1954, beating live oak in palmetto-dominated hammock, 1 ♀; Hendry County, State Highway 833, locality not recorded, 16 April 1954, beating broad-leaved trees and shrubs, and on trunks and foliage of *Sabal palmetto*, 2 ♀, 1 nymph; Highlands County, Highlands Hammock State Park, 3 March 1956, beating dead cabbage palm leaves in hammock, 4 ♀; Indian River County, Vero Beach, 18 April 1954, beating broad-leaved shrubs and trees and *Sabal palmetto* leaves in dune hammock, 5 ♀; Levy County, Seahorse Key, 28 June 1953, beating broad-leaved shrubs, 1 ♀; Inglis, collected 9 June 1965 from laboratory culture from this locality, 5 ♀; Polk County, Avon Air Force Base, 4 March 1956, beating saw palmetto leaves in cypress dome, 1 nymph; Sarasota County, Myakka River State Park, 30 August 1951, *ex* cabbage palm trunk, 1 ♀. Louisiana: Orleans Parish, New Orleans, 1 December 1965, beating vegetation in Audubon Park, 1 ♀. MEXICO: San Luis Potosi, Tamazunchale, 18 June 1966, beating ferns, bromeliads, and cabbage palms, 6 ♀, E. L. Mockford, R. Sloan and A. Manzano collectors. Tabasco, 4 miles southwest of Frontera, 3 July 1966, beating cacao foliage, 1 ♀.

Note.—The species was reared in culture at this laboratory through several generations in 1966. It proved to be obligatorily thelytokous, lacking males entirely.

Liposcelis pallidus Mockford, new species

Diagnosis.—Similar to *L. villosus* Mockford in color and chaetotaxy but differing in sculpture, resembling *L. reticulatus* Badonnel, *L. laparvensis* Badonnel, and *L. discalis* Badonnel in having finely reticulate sculpture on membranous zones of abdomen; but this sculpture irregular in size of reticulations and in relative fineness (Fig. 17). Similar in color to *L. nasus* and *L. pallens* Badonnel, differing from both in details of sculpture and in possessing only one relatively long seta anteriorly on each lateral pronotal lobe in addition to SI.

Female.—Measurements as given in Table 1. Morphology: Region of median suture of vertex not showing a break in sculpture. Eight units in each eye. Lacinial tip as in Fig. 27. Mesothoracic parapsidal sutures not visible. Tg_1 partly obscured by material in digestive tract; visible part appearing uniform in sclerotization. Intersegmental lines 4–5 and 5–6 each marked dorsally in middle by a narrow, dark, double band; a narrower single band marking intersegmental line 6–7. Common trunk of gonapophyses elongate (Fig. 28). T-shaped sclerite as in Fig. 29. Sculpture: Vertex (Fig. 16) with impressed lines enclosing transverse, smooth areoles; occasional short segments of the lines faint or absent. Abdominal terga beset with closely-spaced, small polygonal tubercles; on Tg_6 and Tg_7 these changing abruptly in weakly sclerotized posterior ½ of tergum to faint lines in reticulate pattern becoming bolder more posteriorly (Fig. 17).

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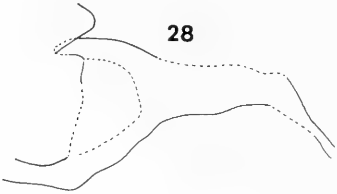

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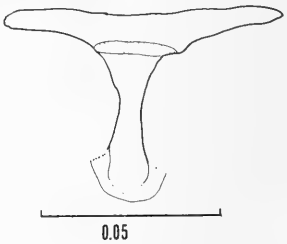

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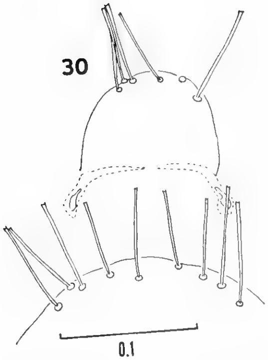

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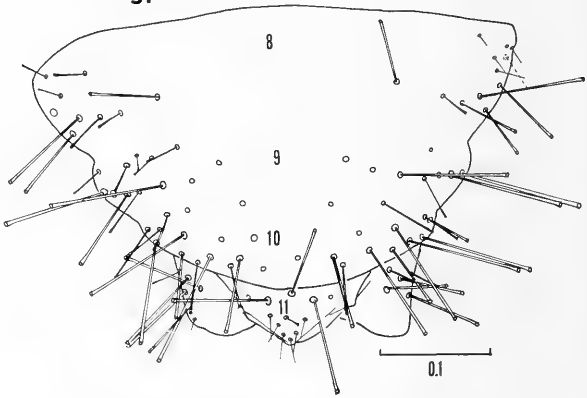


Figs. 27–31. *Liposcelis pallidus* ♀. 27, Lacinial tip, scale of Fig. 29. 28, Common trunk of gonapophyses, scale of Fig. 29. 29, T-shaped sclerite. 30, Thoracic sterna showing chaetotaxy. 31, Abdominal terga 8–11 showing chaetotaxy.

Chaetotaxy: Setae of vertex (Fig. 16) long and tapering to fine points. Pronotum (Fig. 33) with SI approximately parallel-sided and decidedly longer than single other seta of lateral lobe. Other seta of lateral lobe anterior, slightly swollen medially. Meso-metatergum with SII somewhat shorter than SI. Prosternal setae apparently 6 in an anterior arc with 2 lateral setae longest (Fig. 30). Mesosternal row of 9 or 10 setae. Tg_{1-6} bearing very few, scattered, short, pointed setae. Setae of Tg_{8-11} as in Fig. 31. Color (in alcohol 14 years): Eye patches black. Head, body, and appendages generally dull yellow; reddish-brown subcuticular pigment granules scattered along sides of head, thorax and abdomen.

Holotype ♀ and one ♀ paratype, Texas, Jeff Davis County, 8.2 miles southeast of Fort Davis along State Highway 118, 25 July 1962, beating yucca, ELM #2117. The types are in my collection.

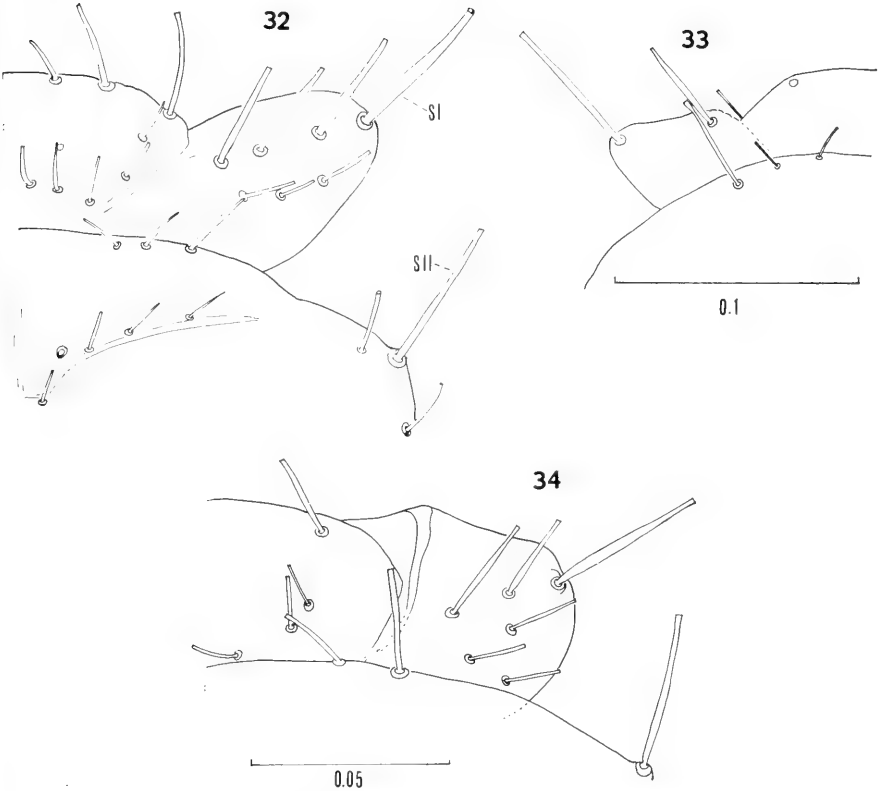


Fig. 32. *Liposcelis ornatus* ♀, right halves of pro- and mesonota showing chaetotaxy, scale of Fig. 34. Fig. 33, *Liposcelis pallidus* ♀, left halves of pro- and mesonota showing chaetotaxy. Fig. 34, *Liposcelis hirsutoides* ♀, right halves of pro- and mesonota showing chaetotaxy.

Section I, Group B, Subgroup Bb

Liposcelis knullei Broadhead

Liposcelis knullei Broadhead, 1971:264.

The species was previously known from Wooster, Ohio and Ottawa, Ontario. With the present record, a wide distribution both north–south and east–west in eastern North America is indicated.

Record.—Texas: Panola County, 5.6 miles south along U.S. Highway 59 from Carthage, 28 November 1975, beating oaks and pines, 2 ♀.

Section II, Group D

Liposcelis bostrychophilus Badonnel

Liposcelis bostrychophilus Badonnel, 1931:251.

The species is widely distributed. In North America, it has been recorded from the boundary area of Georgia and Florida, and from Ottawa, Ontario.

Records.—Texas: Cameron County, State Highway 4, 11 miles east of junction with County Road 511, 30 January 1958, beating dead branches of thorny shrubs on old dune ridges, 1 ♀; Hidalgo County, Bentsen Rio Grande Valley State Park, 28 January 1958, beating palms and branches of thorny trees and shrubs, and sifting ground litter, 24 ♀, 8 nymphs; Kleberg County, Kingsville, 28 August 1977, in stored grain, numerous ♀ and nymphs, R. Schmidt collector; Lee County, 2.5 miles north of Giddings on Highway 77, 10 June 1962, 1 ♀, E. L. Mockford, F. Hill and J. M. Campbell collectors.

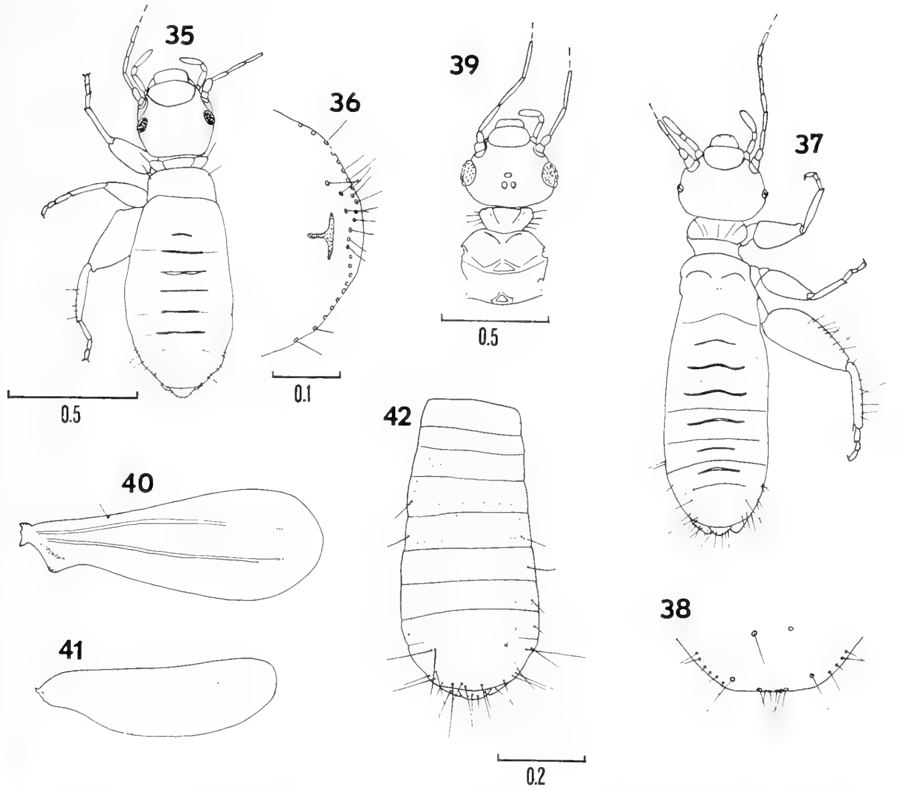
Key to the Texas Species of Liposcelidae

1. Hind femur bearing a lateral protuberance. Female subgenital plate with a T-shaped sclerite. Apterous forms only (Figs. 35 and 36) Subfamily Liposcelinae, genus *Liposcelis* 5
- Hind femur lacking a lateral protuberance. Female subgenital plate without a T-shaped sclerite. Males apterous, females generally in macropterous and apterous forms (Figs. 37–41) Subfamily Embidopsocinae 2

2. Mx4 less than 1.5× as wide in middle as next segment. Tg_{3-8} each with a slender, heavily sclerotized transverse strip (Fig. 37) Genus *Embidopsocus* (*E.* sp.).
- Mx4 at least 1.5× as wide in middle as next segment. Tg_{3-8} lacking sclerotized transverse strips (Fig. 42). Genus *Belaphotroctes* 3

3. Female with Mx4 fully 2× as wide in middle as next segment and bearing on its lower surface 2 groups of closely-set rod-like sensilla (Fig. 43). Corticolous species *Belaphotroctes badonneli* Mockford
- Female with Mx4 about 1.5× as wide in middle as next segment and bearing on its lower surface a single group of closely-set rod-like sensilla, or scattered, short sensilla (Figs. 44, 45). Ground litter species 4

4. Female with 1 group of closely-set rod-like sensilla on lower surface of Mx4 (Fig. 44) *Belaphotroctes hermosus* Mockford
- Female with scattered rod-like sensilla on lower surface of Mx4 (Fig. 45) *Belaphotroctes alleni,* new species



Figs. 35–36. *Liposcelis liparus* ♀. 35, Dorsal view with left legs. 36, Subgenital plate with T-shaped sclerite. Figs. 37–41, *Embidopsocus laticeps* ♀. 37, Dorsal view of apterous female with right legs, scale of Fig. 35. 38, Subgenital plate, scale of Fig. 36. 39, Head and thorax of macropterous female, dorsal view. 40, Forewing of macropterous female, scale of Fig. 35. 41, Hindwing of macropterous female, scale of Fig. 35. Fig. 42, *Belaphotroctes* sp., abdominal terga.

5. Tg$_{3-4}$ uniform in color, not presenting a pale posterior membranous band (Fig. 46) Section I 6
– Tg$_{3-7}$ annulate, i.e., each presenting a pale posterior membranous band with sculpture different from that of anterior portion of tergum (Fig. 47) Section II *Liposcelus bostrychophilus* Badonnel
6. SI of pronotum long and strong, about equal in length to distance between its base and anteromedial margin of lateral pronotal lobe; lateral pronotal lobe with either a transverse row of long, strong setae or a single 1 in addition to SI (Figs. 32–34) Group A 7
– SI of pronotum not so long and strong, in length decidedly less

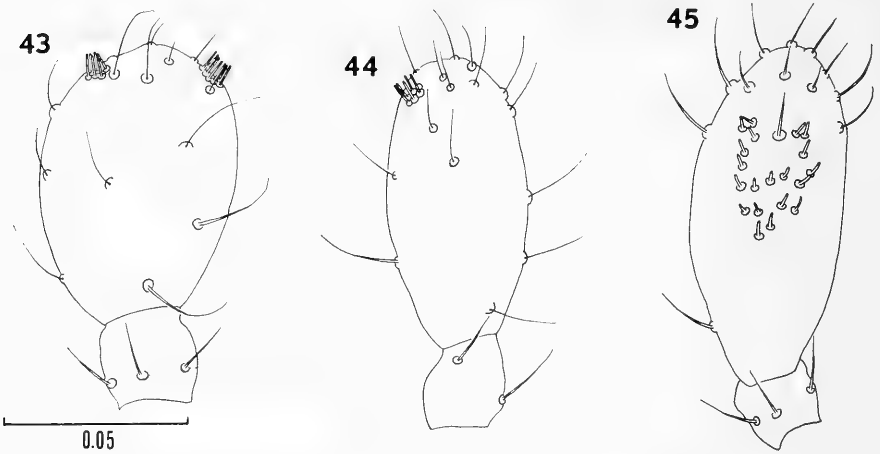


Fig. 43. *Belaphotroctes badonneli* ♀, distal 2 segments of maxillary palpus, ventral view. Fig. 44, *Belaphotroctes hermosus* ♀, distal 2 segments of maxillary palpus, ventral view. Fig. 45, *Belaphotroctes alleni* ♀, distal 2 segments of maxillary palpus, ventral view. All to same scale.

than distance between its base and anteromedial margin of lateral pronotal lobe; all other setae of lateral pronotal lobe much shorter than SI (Fig. 48) Group B 12

7. Two very long, curved, fine setae on epiproct (Fig. 49) *Liposcelis liparus* Broadhead

– Epiproct lacking pair of long, curved, fine setae 8

8. A single long, strong seta on lateral lobe of pronotum in addition to SI (Fig. 33) *Liposcelis pallidus*, new species

– A transverse row of long, strong setae on each lateral lobe of pronotum in addition to SI (Figs. 32 and 34) 9

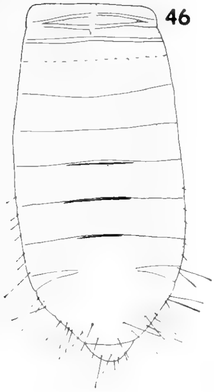
9. Body color essentially uniform pale brown or buffy yellow. 10

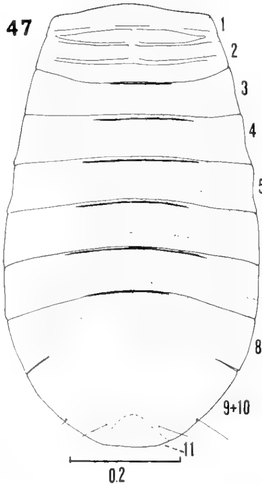
– Body color a contrasting pattern of brown or reddish-brown marks on a creamy white background 11

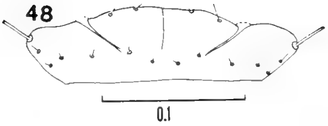
10. Body color pale brown except white on Tg_{1+2} (Fig. 9); short, truncate setae abundant on all abdominal terga (Fig. 50) *Liposcelis hirsutoides*, new species

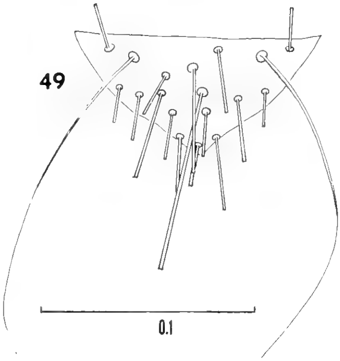
– Body color buffy yellow except anterior ½ of head, gradually darkening to rusty brown on clypeus and labrum; short setae of abdominal terga slender and sparse (Fig. 51) *Liposcelis nasus* Sommerman

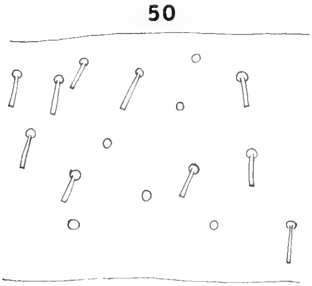
11. Body marked with a series of reddish-brown spots along each side of abdomen (Fig. 11) *Liposcelis deltachi* Sommerman











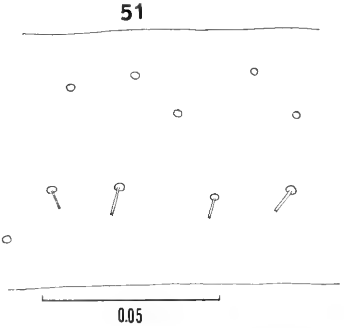


Fig. 46. Abdominal terga of *Liposcelis* species of Section I (*L. simulans* Broadhead shown here), scale of Fig. 47. Fig. 47, Abdominal terga of *Liposcelis* species of Section II (*L. bostrychophilus* shown here). Fig. 48, Pronotal chaetotaxy of *Liposcelis* species of Group B (*L. knullei* shown here). Fig. 49. *Liposcelis liparus* ♀ epiproct. Fig. 50, *Liposcelis hirsutoides* ♀, setae of 5th abdominal tergum in middle, scale of Fig. 51. Fig. 51, *Liposcelis nasus* ♀, setae of 5th abdominal tergum in middle.

– Body marked with variegated brown pattern on head and thorax, a broad, brown crossband on Tg_{3-5}, lateral brown spots on Tg_{9-11} (Fig. 10) *Liposcelis ornatus*, new species

12. Body color medium brown; lacinial tip with inner prong grooved, a short denticle at base of inner prong (Sommerman, 1957, Fig. 1) *Liposcelis lacinia* Sommerman

– Body color dark brown; lacinial tip with inner prong not grooved and lacking a basal denticle *Liposcelis knullei* Broadhead

Acknowledgments

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Department of Biological Sciences, Illinois State University, Normal, Illinois 61761.

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ADDITIONAL APHID–HOST RELATIONSHIPS AT THE LOS ANGELES STATE AND COUNTY ARBORETUM (HOMOPTERA: APHIDIDAE)

Harry G. Walker, Manya B. Stoetzel and Leonid Enari

Abstract.—This is the eighth report on collections of aphids from plants in the Los Angeles State and County Arboretum at Arcadia, California. About 140 species of aphids are listed with information on their host plants, date of collection and abundance.

Aphids are plant feeders and many are efficient vectors of plant viruses. Information on the host plant relationships and distribution of aphids is becoming increasingly important. This is the eighth in a series of papers which contribute to the knowledge of the aphids and their host plants in the Los Angeles State and County Arboretum, Arcadia, California. As in three previous papers (Leonard et al., 1972; Leonard and Walker, 1973 and 1974), this one deals with a variety of aphids and their host plants. Four papers (Leonard et al., 1970, 1971a, 1971b and 1971c) dealt with six specific aphids and their host plants.

Walker has been responsible for the collection of the aphids and Enari for the identification of the host plants. In this report, Stoetzel is responsible for the identification of some of the aphids and for help in the publication. In addition the authors would like to express their deep appreciation to the following for the identification of many of the aphids included in this report: R. L. Blackman (RLB), T. L. Bissell (TLB), C. S. Wood-Baker (W-B), V. F. Eastop (VFE), A. K. Ghosh (AKG), T. Kono (Kono), M. D. Leonard (MDL) deceased, R. J. Nielson (RJN), F. W. Quednau (FWQ), A. G. Robinson (AGR), C. F. Smith (CFS) and D. J. Voegtlin (DJV).

Aphid, host plant relationships at the Los Angeles State and County Arboretum are given and include a list of the aphid, the host, the date of collection, the relative abundance of the aphid and the initials of the person making the aphid identification.

Acyrthosiphon (*Metopolophium*) *dirhodus* (Walker)
  Bromus carinatus Hook. & Arn.
  3/IV/71 Abundant (CFS)

Acyrthosiphon pelargonii (Kaltenbach)
  Pelargonium quercifolium Baum.
  24/XI/69 Moderate (AKG)
  Stereospermum kunthianum Cham.
  15/IX/69 Abundant (W-B)

Acyrthosiphon pisum (Harris)
  Acacia gillii Maiden & Blakely
  2/XI/67 Moderate (MDL)
  Sophora tetraptera F. Mill.
  13/V/69 Scarce (AKG)

Teucrium scorodonia L.
23/II/70 Scarce (RJN)

Acyrthosiphon (*Rhodobium*) *porosus* (Sanderson)

Rosa hugonis Hemsl.
17/III/71 Abundant (MBS)

Rosa sp.
4/XII/69 Abundant (MBS)

Tecoma fulva G. Don
1/V/69 Abundant (W-B)

Acyrthosiphon sp.

Rhamnus californica Eschsch.
31/XII/69 Scarce (AKG)

Amphorophora rubitoxica Knowlton

Rubus palmatus Thunb.
18/V/76 Abundant (RLB)

Amphorophora sp.

Callitris propinqua R. Br.
20/I/71 Abundant (Kono)

Hymenanthera dentata R. Br.
13/V/70 Moderate (RJN)

Salvia microphylla HBK
20/III/70 Moderate (RJN)

Aphis armoraciae Cowen

Conyza bonariensis (L.) Cronq.
11/XI/73 Moderate (CFS)

Aphis sp. near *armoraciae* Cowen

Conyza bonariensis (L.) Cronq.
30/IX/75 Abundant (RLB)

Aphis cephalanthi Thomas

Clerodendrum trichotomum Thunb.
27/VI/69 Moderate (RJN)

Salvia greggii A. Gray
23/I/69 Abundant (RJN)

Aphis citricola van der Goot

Acacia albida Lindl.
30/X/70 Scarce (AKG)

Actinostrobus pyramidalis Miq.
25/IV/68 Moderate Vagrant (VFE)

Aesculus pavia L.
11/III/70 Scarce (AKG)

Agathis palmerstoni F. Muell.
3/VI/68 Moderate (VFE)

Aloe wickensii Pole-Evans
27/XII/69 Moderate (AKG)

Aloysia triphylla (L'Hér.) Britt.
28/IV/70 Moderate (RJN)

Araucaria heterophylla (Salisb.) Franco
27/III/70 Scarce (VFE)

Bauhinia blakeana Dunn
29/X/70 Moderate (AKG)

Britoa guazumifolia Diego Legrand
19/VI/70 Moderate (AKG)

Broussonetia papyrifera Vent.
24/VI/70 Moderate (AKG)

Buddleia saligna Willd.
16/VI/70 Scarce (AKG)

Buxus microphylla Sieb & Zucc. var. japonica (Muell. Arg.) Rehd. & E. H. Wils.
25/VI/70 Abundant (AKG)

Callicarpa dichotoma (Lour.) C. Koch
30/XII/69 Scarce (RJN)

Callitris propinqua R. Br.
30/V/68 Vagrant (VFE)
26/V/69 Vagrant (VFE)

C. rhomboidea R. Br.
5/VI/70 Vagrant (VFE)

Calocedrus decurrens (Torr.) Florin
24/IV/71 Vagrant (VFE)

Calodendrum capense (L.F.) Thunb.
5/V/70 Moderate (AKG)

Camptotheca acuminata Decne.
14/VII/70 Scarce (AKG)

Carissa grandiflora DC.
28/VI/68 Moderate Vagrant (VFE)

Cassia abbreviata D. Oliver subsp. beareana (Holmes) Brenan
7/VI/68 Scarce (VFE)

C. bicapsularis L.
17/III/70 Abundant (AKG)

C. excelsa Schrad
11/III/70 Scarce (AKG)

Catalpa bignonioides Walt.
15/V/69 Scarce Vagrant (VFE)

Cedrus deodara (D. Don) G. Don
29/IV/69 Moderate Vagrant (VFE)

Celastrus loeseneri Rehder & Wilson
2/VII/70 Abundant (AKG)

Chamaecyparis lawsoniana (A. Murr.) Parl.
4/VII/69 Moderate Vagrant (VFE)
C. nootkatensis (D. Don) Spach
1/VII/69 Moderate Vagrant (VFE)
Chamelaucium ciliatum Desf.
5/V/72 Abundant (AKG)
Chomelia obtusa Cham. & Schlect.
16/III/70 Abundant (AKG)
Chorisia insignis HBK
19/II/70 Scarce (AKG)
Cistus incanus L.
20/IV/70 Scarce Vagrant (VFE)
Citharexylum myrianthum Cham.
19/VII/69 Scarce (RJN)
Citrus australis Planch.
27/III/70 Abundant (AKG)
C. 'Sweet Tangor'
8/IV/70 Abundant (VFE)
Clerodendrum japonicum (Thunb.) Sweet
18/VI/69 Moderate (RJN)
C. nutans Wallich
10/XI/70 Scarce (RJN)
C. trichotomum Thunb.
27/VI/69 Moderate (RJN)
11/VII/70 Scarce (RJN)
Cleyera japonica 'Tricolor'
19/VI/69 Scarce (AKG)
Cocculus laurifolius DC.
26/VI/70 Moderate (AKG)
Combretum microphyllum Klotzsch.
13/VI/70 Moderate (AKG)
Cotoneaster cooperi Marquand
29/VI/70 Abundant (AKG)
C. frigidus Wall.
24/VI/69 Abundant (AKG)
C. pannosus French.
11/XII/69 Abundant (AKG)
C. wardii W. W. Smith
6/III/75 Abundant (RLB)
Crataegus laevigata 'Pauls' Scarlet'
23/V/75 Abundant (RLB)
Cryptocarya rubra Skeels
16/III/70 Abundant (AKG)
Cryptomeria japonica 'Araucarioides'
22/IV/71 Scarce Vagrant (VFE)
C. japonica 'Viminalis'
22/IV/71 Moderate (VFE)
Cryptostegia grandiflora R. Br.
4/I/71 Moderate (Kono)
Cupressus cashmeriane Royle
17/IV/71 Abundant Vagrant (VFE)
C. forbesii Jeps.
13/X/69 Scarce Vagrant (VFE)
C. lusitanica Mill.
17/IV/71 Abundant Vagrant (VFE)
C. pygmaea (Lemm.) Sarg.
1/IV/70 Abundant Vagrant (VFE)
C. sempervirens L.
20/VI/69 Abundant Vagrant (VFE)
Cydonia sinensis Thovin
17/V/76 Abundant (RLB)
Duranta repens L.
26/VI/70 Scarce (RJN)
D. repens 'Alba'
18/XII/68 Moderate (RJN)
19/VII/69 Scarce (RJN)
5/III/70 Abundant (RJN)
D. stenostachya Tod.
30/XII/69 Abundant (RJN)
Echium wildpretti H. Pearson
19/V/69 Scarce Vagrant (VFE)
Eucalyptus amygdalina Labill.
14/V/70 Moderate (AKG)
E. cladocalyx F. Muell.
21/I/71 Moderate (Kono)
Euonymus europaea L.
7/X/76 Scarce (RLB)
Ficus sakalavarum Baker
19/III/70 Scarce (AKG)
Gardenia globosa Hochst.
14/I/71 Abundant (Kono)
Hymenosporum flavum F. Muell.
20/I/75 Abundant (RLB)
4/III/75 Abundant (RLB)
Jasminum subhumile W. W. Smith
26/VI/69 Scarce (AKG)
Juniperus chinensis 'Armstrongii'
19/V/69 Scarce Vagrant (VFE)
J. chinensis 'Blaauw'
2/V/70 Scarce Vagrant (VFE)

J. chinensis 'Fruitlandii'
19/V/69 Scarce Vagrant (VFE)

J. scopulorum 'Lakewood Globe'
19/V/69 Scarce Vagrant (VFE)

Malus floribunda Siebold
30/VI/69 Moderate (AKG)
16/IX/70 Abundant (AKG)
5/III/77 Moderate (RLB)

M. ionensis (A. Wood) Britt.
23/V/70 Abundant (AKG)

Ophiopogon japonicus Ker.-Gawl.
16/IV/69 Scarce (AKG)

Oreopanax peltatus Linden
8/I/69 Abundant (AKG)

Osmaronia cerasiformis Greene
24/VI/69 Moderate (AKG)

Owenia acidula F. Muell.
29/V/69 Scarce (AKG)

Paulownia fortunei (Seem.) Hance
20/VI/69 Scarce (AKG)

Peltophorum africanum Sond.
18/VI/69 Abundant (AKG)

Phaedranthus buccinatorium Miers
19/VI/69 Scarce (AKG)

Phellodendron lavallei Dode
26/VI/69 Abundant (AKG)

Physalis floridana Rydb.
17/XII/69 Scarce (AKG)

Pittosporum daphniphylloides Hayata
14/I/71 Moderate (Kono)

P. mannii Hook.
5/III/75 Abundant (RLB)

Poncirus trifoliatus Rafin
6/VI/69 Scarce (AKG)

Prunus caroliniana (Mill.) Ait.
19/V/69 Abundant (RLB)

P. mahaleb L.
9/VI/69 Abundant (RLB)

P. yedoensis Matsum.
23/VI/69 Scarce (AKG)

Pseudocydonia sinensis C. K. Schneider
15/I/69 Abundant (AKG)

Pseudopanax ferox T. Kirk.
24/VI/69 Abundant (AKG)

Psidium sp.
18/VII/69 Moderate (AKG)

Pyracantha coccinea M. J. Roem.
5/I/71 Scarce (Kono)

P. koidzumii (Hayata) Rehder
8/VII/69 Abundant (AKG)

Pyracomeles vilmorini Rehder
13/III/69 Abundant (AKG)

Pyrus kawakamii Hayata
7/X/76 Abundant (RLB)

P. sikkimensis (Wenz.) Kochne
14/VI/69 Abundant (AKG)

Raphiolepis indica Lindl.
6/III/75 Abundant (RLB)

Rhus chinensis Mill.
8/VII/69 Scarce (AKG)

Rosa pendulina L.
9/III/76 Scarce (MBS)

R. pisocarpa A. Gray
23/II/71 Abundant (MBS)

R. spinosissima L.
10/VII/68 Scarce (MBS)

Rosa sp.
29/VI/69 Abundant (MBS)

Salvia greggii A. Gray
10/VII/68 Scarce (RJN)
28/IX/70 Abundant (RJN)
30/XII/70 Scarce (RJN)

S. mellifera Greene
21/II/70 Abundant (RJN)

S. microphylla HBK
21/IV/69 Scarce (RJN)
26/III/70 Abundant (RJN)

S. officinalis L.
16/VII/69 Scarce (RJN)

S. purpurea Cav.
8/I/70 Moderate (RJN)

Schefflera arboricola Hayata
9/X/76 Abundant (RLB)

Sorbus aria (L.) Crantz.
19/V/76 Abundant (RLB)

Spiraea chamedryfolia L.
3/I/69 Abundant (AKG)

S. trilobata L.
20/VI/69 Moderate (W-B)

Stranvaesia nussia Decne.
4/IV/69 Moderate (AKG)

Tabebuia impetiginosa 'Roxo'
19/VII/69 Scarce (AKG)
Teucrium chamaedrys L.
22/III/69 Moderate (RJN)
Trema guinensis Priemer
5/I/71 Scarce (Kono)
Ulmus laevis Pall.
8/VII/69 Scarce (AKG)
Viburnum judii Rehder.
9/VI/69 Abundant (AKG)
V. macrocephalum Fort.
3/IV/69 Scarce (AKG)
V. odoratissimum Ker.-Gawl.
6/III/75 Abundant (RLB)
7/X/76 Abundant (RLB)
5/III/77 Abundant (RLB)
V. rufidulum Raf.
24/VI/69 Abundant (AKG)
V. tinus L.
6/III/75 Abundant (RLB)
24/VI/69 Moderate (AKG)
Vitex negundo L.
21/VI/69 Abundant (AKG)
Watsonia sp.
17/V/69 Scarce (AKG)
Weigela floribunda 'Variegata'
8/VII/69 Moderate (AKG)

Aphis craccivora Koch
Abutilon mauritianum Sweet.
23/IX/70 Abundant (W-B)
Acacia farnesiana Willd.
7/V/70 Scarce (W-B)
A. pinnata Willd.
11/IV/66 Moderate (MDL)
Callistemon acuminatus Cheel.
28/V/70 Scarce (AKG)
Caragana densa Kom.
13/VII/70 Abundant (AKG)
Colutea istria Mill.
7/VII/70 Abundant (AKG)
Cupressus lindleyi Klotzsch.
17/IV/71 Abundant Vagrant (VFE)
Cytisus sp.
23/V/75 Abundant (RLB)
Indigofera australis Willd.
17/VI/70 Moderate (W-B)
I. gerardiana R. Grah.
10/X/71 Abundant (Kono)
Juniperus chinensis 'Viridis'
27/V/71 Abundant (AKG)
Phaseolus caracalla L.
2/X/75 Abundant (RLB)
Pittosporum phillyraeoides DC.
7/X/76 Moderate (RLB)
Salsola iberica Sinnen & Pall.
9/V/69 Moderate (W-B)

Aphis fabae Scopoli
Achillea tomentosa L.
20/V/76 Abundant (RLB)
Agave sp.
23/V/75 Abundant (RLB)
Althaea setosa Boiss.
28/XII/70 Moderate (W-B)
Bulbinella robusta Kunth.
5/III/75 Abundant (RLB)
Cordia cylindristachya Roem. & Schult.
4/I/71 Scarce (Kono)
Cynara cardunculus L.
19/V/76 Abundant (RLB)
Eucalyptus maidenii F. J. Muell.
8/III/77 Abundant (RLB)
Spathodea campanulata Beauv.
31/III/69 Abundant (W-B)
Tecoma fulva G. Don.
1/V/69 Abundant (W-B)
Tulipa gesneriana L.
1/IV/69 Abundant (W-B)
6/III/75 Abundant (RLB)

Aphis gossypii Glover
Abutilon indicum Sweet.
16/VI/70 Abundant (W-B)
A. mauritianum Sweet.
27/IX/68 Moderate (AKG)
23/IX/70 Abundant (W-B)
Achillea tomentosa L.
13/V/69 Scarce (AKG)
Agave sp.
7/II/70 Abundant (W-B)
Aloe ciliaris Haw.
19/II/70 Abundant (AKG)
Amelanchier sanguinea DC.
12/XII/70 Abundant (W-B)

Arctostaphylos oppositifolia Parry
30/XII/70 Abundant (W-B)

Aspidosperma australe Muell.
13/V/70 Scarce (AKG)

Bidens vulgatus Greene
7/II/70 Abundant (W-B)

Bombax sp.
5/X/70 Moderate (W-B)

Bowkeria gerardiana Harv.
10/VI/68 Scarce Vagrant (VFE)

Buddleia saligna Willd.
16/VI/70 Scarce (AKG)

Callistemon acuminatus Cheel.
28/V/70 Scarce (AKG)

C. phoeniceus Lindl.
2/X/75 Abundant (RLB)

Calotropis procera Ait.
15/XII/70 Moderate (W-B)

Camellia sinensis Kuntze
22/IX/70 Abundant (W-B)

Cassia abbreviata D. Oliver subsp. beareana (Holmes) Brenan
7/VI/68 Scarce (VFE)

C. nemophila coriacea Symon.
15/I/71 Moderate (Kono)

Catalpa bignonioides Walt.
15/V/69 Scarce Vagrant (VFE)

C. bungei C. A. Mey.
16/X/70 Abundant (AKG)

C. speciosa Warder
29/IX/75 Moderate (RLB)

Ceiba pentandra Gaertn.
12/XI/70 Abundant (AKG)

Celtis willdenowiana Roem. & Schult.
23/VII/70 Abundant (W-B)

Celtis sp.
6/VII/70 Abundant (W-B)

Centranthus ruber DC.
23/II/70 Abundant (W-B)
19/VII/70 Abundant (AKG)

Chiranthodendron pentadactylon Larreat.
29/I/70 Scarce (W-B)

Cissus antartica Venten.
3/XI/70 Scarce (AKG)

Clematis armandii Franch
20/VI/70 Abundant (W-B)

C. stans Sieb. & Zucc.
18/VI/70 Scarce (AKG)

Clerodendrum trichotomum Thunb.
27/VI/69 Moderate (RJN)
11/VII/70 Scarce (RJN)

Cordia cylindristacha Roem. & Schult.
4/I/71 Scarce (Kono)

Cordyline rubra Hueg.
28/V/69 Moderate (AKG)

Coreopsis tinctoria Nutt.
24/VII/70 Abundant (W-B)

Cotoneaster dammeri 'Skogsholmen'
13/VII/70 Abundant (W-B)

C. henryanus (C. K. Schneid.) Rehd. & Wils.
13/VIII/68 Scarce (AKG)

C. salicifolius Franch
5/VII/70 Abundant (W-B)

Crassula argentea Thunb.
11/XI/70 Abundant (W-B)

Crataegus lavallei Herincq
25/IV/70 Abundant (W-B)

Crotalaria retusa L.
28/V/70 Abundant (W-B)

Crowea exalata F. Muell.
29/XII/70 Scarce (W-B)

Cucurbita foetidissima HBK
28/X/70 Abundant (AKG)

Echium fastuosum Jacq.
5/I/71 Moderate (Kono)

E. wildpretti H. Pearson
19/V/69 Scarce Vagrant (VFE)

Eucalyptus leucoxylon F. J. Muell.
20/I/71 Abundant (Kono)

E. sideroxylon A. Cunn.
20/I/71 Moderate (Kono)

E. stowardii Maiden
30/IX/75 Abundant (RLB)

Euonymus japonica Thunb.
22/IV/70 Scarce (AKG)

Forsythia 'Lynwood Gold'
6/I/71 Moderate (Kono)

Hibiscus hamabo Sieb. & Zucc.
4/I/71 Abundant (Kono)

H. syriacus 'Paeonaeaflorus'
6/I/71 Moderate (Kono)

Hypericum chinense L.
3/II/70 Scarce (AKG)

Leptospermum patersonii F. M. Bailey
14/I/71 Scarce (Kono)

Liquidambar orientalis Mill.
14/I/71 Abundant (Kono)

Manfreda maculosa (Hook.) Rose
7/V/70 Abundant (W-B)

Parmentiera edulis DC.
18/VII/69 Scarce (AKG)

Phlomis taurica Hartwiss
15/III/69 Scarce (AKG)

Pittosporum sp.
14/I/71 Abundant (Kono)

Plumeria rubra L.
21/III/69 Scarce (AKG)

Rosa banksiae Ait. f.
24/IV/70 Scarce (MBS)

R. 'Margo Koster'
22/V/68 Abundant (MBS)

R. 'Wind Chimes'
9/III/76 Abundant (MBS)

Rudbeckia hirta L.
29/IX/69 Moderate (W-B)

Ruttya fruticosa Lindau.
16/V/69 Scarce (AKG)

Solanum robustum H. Wendl.
15/III/69 Moderate (AKG)

Stigmaphyllon affine A. Juss.
1/X/75 Abundant (RLB)

Tecoma fulva G. Don
1/V/69 Abundant (W-B)

T. mollis HBK
19/VII/69 Scarce (AKG)

Xylosma congestum (Lour.) Merrill
8/IV/69 Scarce (AKG)

Aphis helianthi Monell

Ribes aureum Pursh var. gracillimum (Cov. & Britt.) Jeps.
21/XI/69 Abundant (W-B)

Schefflera arboricola Hayata
27/III/69 Abundant (W-B)

Schinus terebinthifolius Raddi
18/VI/68 Scarce (W-B)

Aphis sp. probably *helianthi* Monell

Raphiolepis indica 'Tashiroi'
31/I/69 Abundant (W-B)

Sanguisorba minor Scop.
21/VII/70 Moderate (W-B)

Aphis ilicis Kaltenbach

Ilex cassine L.
24/XI/71 Abundant (W-B)

Aphis maidiradicis Forbes

Portulaca oleracea L.
8/IX/72 Abundant (CFS)

Aphis sp. near *maidiradicis* Forbes

Sonchus oleraceus L.
30/IX/75 Abundant (RLB)

Portulaca oleracea L.
29/IX/75 Abundant (RLB)

Aphis nasturtii Kaltenbach

Acacia arabica Willd.
6/VI/69 Moderate (W-B)

Catalpa japonica Dode
10/VII/70 Scarce (AKG)

Aphis sambuci L.

Aloysia triphylla (L'Hér) Britt.
8/XII/69 Scarce (RJN)

Duranta repens 'Alba'
5/III/70 Abundant (RJN)

Sambucus kamtschatica E. Wolf.
24/X/69 Abundant (W-B)

Aphis sedi Kaltenbach

Sedum spectabile Bor.
4/II/69 Abundant (W-B)

Aphis sp.

Albizia procera Benth.
13/VI/70 Scarce (W-B)

Amaranthus graecizans L.
2/X/72 Abundant (CFS)
30/IX/75 Abundant (RLB)

Angianthus tomentosus Wendl.
4/III/75 Abundant (RLB)

Basancantha spinosa K. Schum.
14/I/71 Scarce (Kono)

Carya ovata (Mill.) C. Koch
1/VII/68 Scarce (TLB)

Celtis africana Burm.
5/III/75 Abundant (RLB)

Cerastium tomentosum L.
13/II/70 Moderate (RJN)

Clarkia amoena A. Nelson & MacBride
2/X/75 Abundant (RLB)

Cupressus lusitanica Mill.
23/V/70 Scarce Vagrant (VFE)
17/IV/71 Abundant Vagrant (VFE)

Cussonia paniculata Eckl. & Zeyh.
20/I/75 Moderate (RLB)

Dioscorea floribunda Mart. & Gal.
6/I/71 Moderate (Kono)

Echeveria gibbiflora DC
20/I/75 Abundant (RLB)

Erigeron linifolius Willd.
7/II/75 Abundant (CFS)

Eriobotrya deflexa (Hemsl.) Nakai var. koshunensis Kaneh. & Sasaki
23/V/75 Abundant (RLB)

Eucalyptus niphophila Maiden & Blakely
6/I/71 Moderate (Kono)

Rothmannia globosa (Hochst.) Keay
23/V/75 Scarce (RLB)

Hovenia dulcis Thunb.
5/III/77 Scarce (RLB)

Juglans californica Wats.
26/III/68 Abundant (TLB)
16/VI/69 Abundant (TLB)

Juniperus scopulorum 'Moffeti'
2/V/70 Abundant (DJV) (VFE)

Pinus halepensis Mill.
10/X/68 Moderate (VFE)

Pittosporum bicolor Hook.
14/I/71 Moderate (Kono)

Podocarpus falcatus (Thunb.) R. Br.
16/VI/70 Scarce (VFE)

P. macrophyllus (Thunb.) D. Don
22/VI/70 Moderate (VFE)

Portulaca oleracea L.
19/IX/74 Moderate (CFS)

Pterocarya fraxinifolia (Lam.) Spach
5/IV/68 Scarce (TLB)
3/IX/70 Scarce (TLB)

P. rehderiana C. K. Schneider
30/III/68 Moderate (TLB)
27/VI/70 Scarce (TLB)

P. rhoifolia Sieb. & Zucc.
16/VII/70 Scarce (TLB)
22/III/70 Moderate (TLB)

Pyracomeles vilmorini Rehder
5/I/71 Abundant (Kono)

Salix matsudana 'Umbraculifera'
6/I/71 Moderate (Kono)

Senecio alpinus L.
5/I/71 Abundant (Kono)

Stranvaesia nussia Decne.
11/VI/69 Abundant (W-B)

Teucrium scorodonia L.
23/III/70 Scarce (RJN)

Aphis (*Cerosipha*) sp.

Eucalyptus delegatus R. T. Baker
29/IV/75 Abundant (RLB)

Viburnum odoratissimum Ker.-Gawl.
17/I/75 Abundant (RLB)

Aphis (*Zyxaphis*) sp.

Euphorbia supina Rafin
30/IX/75 Scarce (RLB)

Appendiseta robinea (Gillette)

Robinia pseudoacacia L.
25/VII/69 Scarce (AKG)

Aulacorthum solani (Kaltenbach)

Aesculus pavia L.
11/III/70 Scarce (AKG)

Aloysia triphylla (L.'Hér.) Britt.
8/XII/69 Scarce (RJN)
28/IV/70 Moderate (RJN)

Argania spinosa (L.) Skeels
6/VI/69 Scarce (AKG)

Asparagus setaceus (Kunth) Jessop
2/IV/69 Scarce (AKG)

Cassia atomaria L.
17/III/70 Abundant (W-B)

C. bicapsularis L.
17/III/70 Abundant (AKG)

Cerastium tomentosum L.
13/V/69 Scarce (RJN)

Clerodendrum nutans Wall.
10/XI/70 Scarce (RJN)

Coreopsis lanceolata L.
28/IV/69 Moderate (AKG)

Dianthus 'China Doll'
12/II/70 Moderate (RJN)

D. deltoides L.
8/IV/69 Abundant (RJN)

Dieffenbachia picta Schott.
3/VI/69 Moderate (W-B)

Duranta repens L.
5/III/70 Moderate (RJN)

D. repens 'Alba'
18/XII/68 Moderate (RJN)
31/XII/70 Moderate (RJN)

D. stenostachya Tod.
5/III/70 Abundant (RJN)

Hagenia abyssinica J. F. Gmel.
6/IV/69 Moderate (RJN)
16/VI/70 Abundant (RJN)

Hymenanthera dentata R. Br.
13/V/70 Moderate (RJN)

Nephrolepsis exaltata Schott
23/III/75 Scarce (AGR)

Phlomis caucasica K. H. Rechinger
8/IV/69 Abundant (AKG)

Pieris taiwanensis Hayata
4/IV/69 Moderate (AKG)

Polygonum chinense L.
16/IV/69 Moderate (AKG)

Rhamnus frangula L.
15/I/69 Moderate (W-B)

Rudbeckia hirta L.
29/IX/69 Moderate (W-B)

Rumex crispus L.
12/III/69 Moderate (W-B)

Salvia microphylla HBK
26/III/70 Abundant (RJN)

Santolina virens Mill.
17/IV/69 Scarce (W-B)

Solanum dulcamara L.
24/XI/Abundant (W-B)

Spathodea campanulata Beauv.
31/III/69 Abundant (W-B)

Tagetes patula L.
5/V/69 Moderate (AKG)

Teucrium scorodonia L.
23/II/70 Scarce (RJN)

Viola cornuta L.
3/VI/69 Scarce (RJN)

V. wittrockiana Gams.
13/II/70 Scarce (RJN)

Aulacorthum (*Neomyzus*) *circumflexum* (Buckton)

Artemisia dracunculus L.
25/II/70 Moderate (AKG)

Aulacorthum sp.

Cedrus deodara (D. Don) G. Don
29/IV/69 Moderate Vagrant (VFE)

Brachycaudus (*Acaudus*) *cardui* (L.)

Chrysanthemum maximum Ramond
15/X/70 Abundant (W-B)

Brachycaudus helichrysi (Kaltenbach)

Achilla taygetea Boiss & Heldr.
12/II/70 Abundant (W-B)

Athanasia parviflora L.
5/V/70 Abundant (AKG)

Brassaia actinophylla Endl.
1/VIII/69 Abundant (W-B)

Chrysanthemum balsamita L.
21/II/70 Scarce (AKG)

Cordia cylindristachya Roem. & Schult.
4/I/71 Scarce (Kono)

Rhus sylvestris Sieb. & Zucc.
14/VIII/68 Moderate (W-B)

Senecio mikanioides Otto
21/IV/69 Abundant (W-B)

Brevicoryne brassicae (L.)

Actinidia chinensis Planch.
26/III/70 Scarce (AKG)

Brassica campestris Oed.
10/II/70 Abundant (AKG)

B. rapa L.
23/V/70 Abundant (W-B)

Raphanus sativus L.
8/V/69 Abundant (W-B)

Calaphis betulella Walsh

Betula papyrifera Marsh.
2/V/67 Moderate (FWQ)

Calaphis flava Mordvilko

Achillea tomentosa L.
18/IV/71 Abundant (VFE)

Betula andrewsii A. Nelson
27/VI/70 Moderate (AKG)

B. davurica Pall.
18/V/76 Abundant (RLB)
4/X/76 Scarce (RLB)
5/III/77 Scarce (RLB)
B. forrestii Hand-Mazz.
17/V/76 Scarce (RLB)
B. lutea Michx.
8/VIII/67 Scarce (FWQ)
B. maximowicziana Regel.
18/V/76 Scarce (RLB)
B. nigra L.
19/V/76 Scarce (RLB)
B. papyrifera Marsh.
2/V/67 Moderate (FWQ)
5/VI/69 Moderate (VFE)
24/VI/70 Abundant (VFE)
19/V/76 Moderate (RLB)
B. pendula Roth
15/VII/69 Moderate (VFE)
B. pendula 'Dalecarlica'
3/VII/69 Moderate (VFE)
B. pendula 'Fastigata'
5/VI/70 Abundant (VFE)
B. pendula 'Tristis'
10/VI/69 Abundant (VFE)
2/VIII/70 Abundant (VFE)
19/V/76 Scarce (RLB)
B. platyphylla Sukachev
17/V/76 Scarce (RLB)
5/III/77 Scarce (RLB)
B. turkestanica Litw.
19/V/76 Scarce (RLB)
B. pubescens J. F. Ehrh.
11/VI/69 Abundant (VFE)
4/VII/70 Abundant (VFE)
21/IV/71 Moderate (VFE)
Calaphis sp.
Betula jaquemontii Spach.
28/VI/70 Moderate (AKG)
Callipterinella callipterus Hartig
Betula pendula Roth
17/V/76 Moderate (RLB)
7/X/76 Abundant (RLB)
B. pendula 'Dalecarlica'
29/X/70 Abundant (VFE)
Capitophorus elaeagni (del Guercio)
Dianthus 'China Doll'
12/II/70 Moderate (RJN)
Capitophorus sp.
Salix lasiolepis Benth.
11/XII/69 Abundant (AKG)
Teucrium flavum L.
2/IV/69 Scarce (RJN)
Cavariella aegopodii (Scopoli)
Brassaia actinophylla Endl.
1/VIII/69 Abundant (W-B)
Carum carvi L.
25/VI/70 Abundant (W-B)
Euonymus japonica Thunb.
2/IV/70 Scarce (AKG)
Cavariella pustula Essig
Salix matsudana 'Umbraculifera'
6/I/71 Moderate (Kono)
Chaetosiphon fragaefolii (Cockerell)
Baeckea camphorata R. Br.
16/V/70 Moderate (W-B)
Cerastium tomentosum L.
23/X/69 Abundant (RJN)
Rosa banksiae 'Lutea'
5/V/69 Moderate (MBS)
R. centifolia L.
20/V/68 Scarce (MBS)
R. 'Manon Cochet'
9/III/76 Abundant (MBS)
R. 'Newport Fairy'
9/III/76 Moderate (MBS)
R. picoscarpa A. Gray
23/II/71 Abundant (MBS)
9/III/76 Abundant (MBS)
R. 'Wind Chimes'
9/III/76 Abundant (MBS)
Chromaphis juglandicola (Kaltenbach)
Pterocarya rhoifolia Sieb. & Zucc.
20/X/69 Scarce (TLB)
Cinara arizonica (Wilson)
Pinus coulteri D. Don
24/VII/69 Abundant (VFE)
P. glabra Walt.
24/IV/71 Scarce (VFE)
P. wallichiana A. B. Jack.
22/IV/71 Abundant (DJV)
Cinara californica Hottes and Essig
Pinus douglasiana Martinez
4/XI/69 Abundant (VFE)

P. duragnensis Roezl.
22/IV/71 Moderate (VFE)

P. glabra Walt
11/XI/69 Abundant (DJV) (VFE)

P. lumholzii Robinson & Fernald
7/XI/69 Abundant (DJV) (VFE)

P. nigra Arnold
23/VII/69 Scarce (DJV) (VFE)

P. occidentalis Sw.
24/IV/71 Abundant (DJV)

P. oocarpa Schiede
29/VII/68 Abundant (DJV)
31/X/69 Abundant (DJV)

P. patula Schlechtend. & Cham.
5/XI/69 Abundant (VFE)

P. roxburghii Sarg.
26/XI/69 Abundant (VFE)
5/III/70 Abundant (VFE) (DJV)

Cinara fresai E. E. Blanchard

Cupressus macnabiana A. Murr.
19/VI/68 Scarce (VFE)

C. pygmaea (Lemm.) Sarg.
1/IV/70 Abundant (VFE)

C. sempervirens 'Stricta'
5/VI/71 Scarce (VFE)

Juniperus chinensis 'Armstrongi'
19/V/69 Scarce (VFE)

J. chinensis 'Blaauw'
19/V/69 Scarce (VFE)
2/V/70 Scarce (VFE)
27/V/71 Abundant (VFE)

J. chinensis 'Columnaris Glauca'
4/V/70 Scarce (VFE)

J. chinensis 'Hetzii'
1/V/70 Abundant (VFE)
26/V/71 Abundant (VFE)

J. chinensis 'Keteleeri'
27/V/71 Abundant (VFE)

J. chinensis 'Pfitzeriana'
6/V/69 Abundant (VFE)
24/II/70 Abundant (VFE)

J. chinensis 'Pfitzeriana Aurea'
19/V/69 Moderate (VFE)

J. chinensis 'Robusta Green'
26/III/70 Moderate (VFE)

J. chinensis 'Sea Green'
26/V/71 Abundant (VFE)

J. chinensis 'Winter Green'
14/III/70 Moderate (VFE)

J. chinensis procumbens 'Aureo-variegata'
26/V/71 Scarce (VFE)

J. communis 'Prostrata'
24/V/71 Moderate (VFE)

J. 'Gold Coast'
24/III/69 Abundant (VFE)

J. horizontalis 'Bar Harbor'
19/XI/68 Scarce (VFE)

J. horizontalis 'Hughes'
1/V/70 Abundant (VFE)
27/V/71 Moderate (VFE)

J. horizontalis 'Plumosa Compacta'
1/V/70 Abundant (VFE)

J. monosperma Sargent
27/V/71 Abundant (VFE)

J. occidentalis 'Sierra Silver'
13/III/70 Moderate (VFE)
10/IV/71 Abundant (VFE)

J. sabina 'Arcadia'
13/III/70 Abundant (VFE)
31/V/71 Moderate (VFE)

J. sabina 'Scandia'
24/III/69 Moderate (VFE)
14/III/70 Abundant (VFE)
2/V/70 Moderate (VFE)
7/IV/71 Scarce (VFE)
27/V/71 Scarce (VFE)

J. scopulorum 'Erecta Glauca'
31/III/70 Abundant (VFE)
10/IV/71 Abundant (VFE)

J. scopulorum 'Gray Gleam'
2/V/70 Abundant (VFE)
31/V/71 Moderate (VFE)

J. scopulorum 'Lakewood Globe'
19/V/69 Scarce (VFE)

J. scopulorum 'Rependens'
26/V/71 Abundant (VFE)

J. scopulorum 'Staver'
13/III/70 Abundant (VFE)

J. scopulorum 'Table Top Blue'
19/XI/68 Moderate (VFE)
19/V/69 Moderate (VFE)
1/V/70 Scarce (VFE)
27/V/71 Abundant (VFE)

J. squamata 'Parsoni'
26/V/71 Scarce (VFE)

J. virginiana 'Cupressifolia'
13/III/70 Abundant (VFE)
31/III/70 Scarce (VFE)
10/IV/71 Abundant (VFE)

J. virginiana 'Manhattan Blue'
19/V/69 Moderate (VFE)
2/V/70 Abundant (VFE)
31/V/71 Abundant (VFE)

J. virginiana 'Silver Spreader'
14/III/70 Abundant (VFE)
10/IV/71 Moderate (VFE)

Pinus coulteri G. Don
1/IV/70 Abundant (VFE)

Cinara juniperi (de Geer)

Calocedrus decurrens (Torr.) Florin
24/IV/71 Abundant (VFE)

Cupressus pygmaea Sarg.
1/IV/70 Scarce (VFE)

V. virginiana Burki
26/IV/71 Scarce (VFE)

Cinara pilicornis (Hartig)

Cryptomeria japonica 'Araucarioides'
22/IV/71 Scarce (VFE)

Picea pungens Engelm.
24/IV/71 Abundant (VFE)

Cinara ponderosae (Williams)

Pinus canariensis Sweet
31/X/69 Abundant (VFE)
27/III/70 Moderate (VFE)

P. douglasiana Martinez
4/XI/69 Abundant (VFE)
17/I/75 Abundant (RLB)

P. greggii Engelm.
20/I/75 Abundant (RLB)

P. michoacana Martinez
20/VIII/68 Moderate (VFE) (DJV)
3/II/69 Moderate (VFE) (DJV)

P. nigra Arnold
23/XI/69 Scarce (VFE) (DJV)
26/IV/71 Scarce (VFE) (DJV)

P. occidentalis Sw.
24/IV/71 Abundant (DJV)

P. quadrifolia Parl.
18/V/71 Moderate (VFE) (DJV)
25/V/71 Abundant (VFE) (DJV)

Cinara sibiricae (Gillette and Palmer)

Juniperus scopulorum 'Moffeti'
2/V/70 Abundant (VFE) (DJV)

Cinara tujafilina (del Guercio)

Callitris columellaris F. J. Muell.
13/I/70 Scarce (VFE)

C. rhomboidea R. Br.
29/IV/68 Scarce (VFE)
31/I/71 Moderate (VFE)
4/III/69 Abundant (VFE)
13/I/70 Abundant (VFE)
1/II/71 Abundant (VFE)

C. drummondii Benth.
11/III/69 Moderate (VFE)
27/VIII/68 & 13/I/70 Abundant (VFE)

C. gracilis R. T. Baker
11/III/69 Scarce (VFE)
15/I/70 Abundant (VFE)
1/II/71 Scarce (VFE)

C. morrisonii R. T. Baker
30/IV/68 Scarce (VFE)
28/VIII/68 Abundant (VFE) (RLB)
11/III/69 Abundant (VFE) (RLB)
13/I/70 Moderate (VFE)
1/II/71 Abundant (VFE) (RLB)
1/X/75 Abundant (VFE) (RLB)

C. murrayensis Miq.
13/I/70 Abundant (VFE)
1/II/71 Abundant (VFE)
17/I/75 Moderate (RLB)

C. propinqua R. Br.
31/XII/69 Abundant (VFE)

Chamaecyparis lawsoniana Parl.
4/VII/69 Moderate (VFE) (DJV)
1/IV/70 Scarce (VFE)
31/III/71 Abundant (VFE)
10/III/70 Abundant (VFE)

Cupressus pygmaea Sarg.
1/IV/70 Abundant (VFE)

Juniperus 'Gold Coast'
24/III/69 Abundant (VFE)

Pinus coulteri G. Don
1/IV/70 Abundant (VFE)

Platycladus orientalis (L.) Franco
4/II/69 Abundant (VFE)
14/VI/69 Moderate (VFE)
30/I/70 Abundant (VFE)
1/VII/70 Abundant (VFE)
23/II/71 Abundant (VFE)

Widdringtonia juniperoides Endl
20/I/75 Abundant (RLB)

Cinara wahluca Hottes group
  Cupressus glabra Sudw.
  5/X/70 Abundant (VFE)

Cinara sp.
  Actinostrobus pyramidalis Miq.
  25/IV/68 Moderate (VFE)
  Cedrus deodara Loud.
  29/IV/69 Moderate (VFE)
  Cupressus guadalupensis S. Wats.
  31/III/70 Moderate (VFE)
  Juniperus scopulorum 'Lakewood Globe'
  2/V/70 Abundant (VFE)
  3/V/71 Abundant (VFE)
  Pinus canariensis Sweet
  26/IV/71 Abundant (VFE)
  P. caribaea Morelet
  2/IV/70 Abundant (VFE)
  P. cembroides Zucc.
  22/V/71 Moderate (VFE)
  P. douglasiana Roezl.
  16/XII/73 Moderate (VFE)
  P. durangensis Roezl.
  22/IV/71 Moderate (VFE)
  P. greggii Engelm.
  18/II/69 Scarce (VFE)
  P. muricata D. Don
  2/IV/70 Scarce (VFE) (DJV)

Cinara sp. (Delta)
  Pinus douglasiana Martinez
  4/XI/69 Abundant (DJV)
  P. glabra Walt.
  11/XI/69 Abundant (DJV)
  P. greggii Engelm.
  12/II/71 Abundant (DJV)
  P. lomholzii Robinson & Fernald
  7/XI/69 Abundant (VFE) (DJV)
  P. nigra Arnold
  23/VII/69 Scarce (VFE) (DJV)
  P. occidentalis Sw.
  21/IV/71 Abundant (DJV)
  P. oocarpa Schiede
  29/VII/68 Abundant (DJV)
  31/X/69 Abundant (DJV)
  P. patula Schlechtend. & Cham.
  5/XI/69 Abundant (VFE)
  P. roxburghii Sarg.
  26/XI/69 Abundant (VFE)

Dactynotus ambrosiae (Thomas)
  Baeckea camphorata R. Br.
  16/V/70 Moderate (W-B)
  Brickellia guatemalensis
  B. L. Robinson
  25/IX/70 Abundant (W-B)
  Doronicum pardalianches L.
  20/V/76 Abundant (RLB)
  Santolina virens Mill.
  17/IV/69 Scarce (W-B)

Dactynotus sp.
  Maclura pomifera (Raf.) C. K. Schneid.
  19/VII/70 Moderate (AKG)
  Olearia pimeleoides Benth.
  17/III/69 Abundant (AKG)
  Tanacetum vulgare L.
  24/XI/69 Moderate (AKG)

Drepanaphis sp.
  Acer saccharinum 'Laciniatum'
  16/X/70 Abundant (W-B)

Dysaphis tulipae (Boyer de Fonscolombe)
  Buphthalum salicifolium L.
  5/I/71 Scarce (Kono)

Dysaphis sp.
  Belamcanda chinensis DC.
  23/I/69 Abundant (AKG)
  Osteospermum fruticosum (L.) Norlindh.
  19/III/69 Moderate (AKG)
  Sisyrinchium bellum S. Wats.
  21/XI/69 Abundant (AKG)

Eriosoma lanigerum (Hausmann)
  Malus domestca Baumg.
  29/XI/73 Moderate (CFS)
  Malus sp.
  2/X/75 Abundant (RLB)

Essigella californica (Essig)
  Cedrus deodara (D. Don) G. Don
  29/IV/69 Moderate (VFE)
  Pinus canariensis Sweet
  21/VI/68 Moderate (VFE)
  P. cooperi C. E. Blanco
  4/XI/69 Moderate (VFE)
  P. coulteri G. Don
  1/VIII/68 Moderate (VFE)
  7/XI/69 Abundant (VFE)
  7/X/70 Abundant (VFE)

P. durangensis Roezl.
1/IV/70 Moderate (VFE)
P. douglasiana Martinez
16/XI/73 Moderate (VFE)
17/I/75 Abundant (RLB)
P. halepensis Mill.
5/XI/69 Moderate (VFE)
P. michoacana Martinez
16/XI/73 Abundant (VFE)
1/X/75 Moderate (RLB)
P. wallichiana A. B. Jacks.
31/VII/68 Scarce (VFE)
5/XI/69 Abundant (VFE)
Pinus sp.
3/XI/69 Moderate (VFE)

Essigella essigi Hottes
Pinus canariensis Sweet
24/III/69 Abundant (VFE)
27/III/70 Moderate (VFE)
9/XI/70 Moderate (VFE)
Pinus sp.
3/XI/69 Moderate (VFE)

Essigella fusca Gillette and Palmer
Callitrus drummondii Benth.
31/I/71 Moderate (VFE)
Pinus attenuata Lemm.
4/V/68 Abundant (VFE)
P. coulteri G. Don
24/VII/69 Abundant (VFE)
26/IV/71 Abundant (VFE)

Essigella pini Wilson
Pinus cembroides Zucc.
21/XI/69 Moderate (VFE)
P. cooperi C. E. Blanco
1/IV/70 Scarce (VFE)
24/IV/71 Scarce (VFE)
P. wallichiana A. B. Jacks.
2/IV/70 Scarce (VFE)
7/X/70 Moderate (VFE)
Pinus sp.
27/II/69 Abundant (VFE)
3/XI/69 Moderate (VFE)
31/III/70 Moderate (VFE)
12/II/71 Abundant (VFE)

Essigella sp.
Cupressus lusitanica Hill.
31/X/69 Scarce (VFE)
Picea gemmata Rehder & Wilson
4/XI/69 Scarce (VFE)
Pinus caribaea Morelet
22/VII/69 Abundant (VFE)
5/XI/69 Abundant (VFE)
2/IV/70 Abundant (VFE)
9/X/70 Abundant (VFE)
10/IV/71 Scarce (VFE)
P. douglasiana Martinez
4/XI/69 Abundant (VFE)
P. durangensis Roezl.
22/IV/71 Moderate (VFE)
P. greggii Engelm.
12/II/71 Abundant (DJV) (VFE)
P. lumholzii Robinson & Fernald
7/XI/69 Abundant (DJV) (VFE)
P. michoacana Martinez
20/VIII/68 Moderate (VFE) (DJV)
3/II/69 Moderate (VFE) (DJV)
P. muricata D. Don
2/IV/70 Scarce (VFE) (DJV)
P. nigra Arnold
3/XI/69 Scarce (VFE) (DJV)
26/IV/71 Scarce (VFE) (DJV)
P. occidentalis Sw.
24/IV/71 Abundant (DJV)
P. oocarpa Schiede
31/X/69 Abundant (DJV)
P. patula Schlechtend. & Cham.
5/XI/69 Abundant (VFE)
P. pinea L.
13/X/69 Moderate (VFE)
5/XI/69 Moderate (VFE)
22/IV/71 Moderate (VFE)
P. roxburghii Sarg.
26/XI/69 Abundant (VFE)
5/III/70 Abundant (VFE)
P. sylvestris L.
4/XI/69 Moderate (VFE)
31/III/70 Moderate (VFE)

Eucallipterus tiliae (L.)
Centranthus ruber (L.) DC.
23/II/70 Abundant (W-B)

Euceraphis betulae (Koch)
Betula pendula Roth
17/V/76 Moderate (RLB)
19/V/76 Scarce (RLB)

Euceraphis gilletti Davidson
Alnus koehnei Callier
4/VII/70 Scarce (AKG)
A. rhombifolia Nutt.
5/III/76 Moderate (RLB)
17/V/76 Moderate (RLB)

Eulachnus rileyi (Williams)
Pinus canariensis Sweet
21/VI/68 Moderate (VFE)
24/III/69 Abundant (VFE)
9/XI/70 Moderate (VFE)
P. caribaea Morelet
5/XI/69 Abundant (VFE)
2/IV/70 Abundant (VFE)
9/X/70 Abundant (VFE)
10/IV/71 Scarce (VFE)
P. durangensis Roezl.
22/IV/71 Moderate (VFE)
P. glabra Walt.
11/XI/69 Abundant (DJV) (VFE)
P. greggii Engelm.
31/VII/68 Moderate (VFE)
18/II/69 Scarce (VFE)
11/XI/69 Abundant (VFE)
1/IV/70 Scarce (VFE)
7/X/70 Moderate (VFE)
24/IV/71 Abundant (VFE)
16/XI/73 Abundant (VFE)
20/I/75 Abundant (RLB)
P. halepensis Mill.
2/IV/70 Scarce (VFE)
10/IV/71 Scarce (VFE)
P. halepensis brutia (Ten.) A. Henry
7/II/69 Scarce (VFE)
P. michoacana Martinez
16/XI/73 Abundant (VFE)
17/I/75 Abundant (RLB)
1/X/75 Moderate (RLB)
P. pinea L.
29/VIII/69 Moderate (VFE)
13/X/69 Moderate (VFE)
5/XI/69 Moderate (VFE)
7/X/70 Abundant (VFE)
12/II/71 Abundant (VFE)
22/IV/71 Moderate (VFE)
P. sylvestris L.
3/VIII/68 Moderate (VFE)
22/VII/69 Moderate (VFE)
4/XI/69 Moderate (VFE)
31/III/70 Moderate (VFE)
6/X/70 Scarce (VFE)
P. wallichiana A. B. Jacks.
5/XI/69 Abundant (VFE)
2/IV/70 Scarce (VFE)
Pinus sp.
27/II/69 Abundant (VFE)
12/II/71 Abundant (VFE)
Thuja occidentalis 'Cristata'
11/XI/69 Scarce (VFE)

Euthoracaphis umbellulariae Essig
Cinnamomum brevifolium Miq.
6/III/75 Abundant (RLB)
C. daphnoides Seib. & Zucc.
31/I/69 Abundant (VFE)

Forda formicaria von Heyden
Bromus carinatus Hook. & Arn.
21/I/70 Abundant (CFS)
9/X/70 Abundant (CFS)
1/II/73 Moderate (CFS)

Forda marginata Koch
Agrotis alba L.
3/X/72 Abundant (CFS)
Aristida adscensionsis L.
10/IV/73 Abundant (CFS)
Bromus carinatus Hook. & Arn.
29/I/69 Abundant (CFS)
21/I/70 Abundant (CFS)
13/IX/72 Abundant (CFS)
1/II/73 Moderate (CFS)
26/III/73 Abundant (CFS)
28/III/73 Abundant (CFS)
16/IV/73 Abundant (CFS)
8/V/73 Abundant (CFS)
17/V/73 Abundant (CFS)
11/VI/73 Moderate (CFS)
23/V/75 Abundant (RLB)
30/IX/75 Abundant (RLB)
2/X/75 Abundant (RLB)
17/III/77 Scarce (RLB)
B. catharticus Vahl.
8/V/73 Abundant (CFS)
10/V/73 Abundant (CFS)
18/V/73 Abundant (CFS)
5/VI/73 Abundant (CFS)
B. racemosus L.
6/VI/73 Abundant (CFS)

B. rubens Cav.
12/V/73 Abundant (CFS)
18/V/73 Abundant (CFS)

Cynodon dactylon Pers.
12/V/73 Abundant (CFS)

Echinochloa crus-galli Beauv.
2/IX/72 Abundant (CFS)
8/V/73 Scarce (CFS)
5/VI/73 Abundant (CFS)

Festuca megalura Nutt.
28/III/73 Moderate (CFS)
28/IV/73 Scarce (CFS)

Hordeum stebbinsii L.
10/V/73 Abundant (CFS)

Paspalum dilatatum Poir.
12/V/73 Moderate (CFS)

Poa annua L.
26/III/73 Moderate (CFS)
8/V/73 Moderate (CFS)
12/V/73 Abundant (CFS)
2/V/74 Abundant (CFS)
23/V/75 Abundant (RLB)

Schismus barbatus (L.) Thell.
10/IV/73 Abundant (CFS)

Setaria glauca (L.) Beauv.
14/V/73 Scarce (CFS)

Triticum aestivum L.
5/VI/73 Scarce (CFS)

Hyadaphis erysimi (Kaltenbach)

Capsella bursa-pastoris Medi
17/II/70 Abundant (AKG)

Matthiola incana (L.) R. Br.
8/III/77 Abundant (RLB)

Hyadaphis foeniculi (Passerini)

Oncoba routledgei T. Sprague
4/I/71 Scarce (Kono)

Hyalomyzus monardae (Davis)

Rumex crispus L.
12/III/69 Moderate (W-B)

Hyperomyzus lactucae (L.)

Picris echioides L.
10/V/69 Abundant (AKG)

Hysteroneura setariae (Thomas)
Bougainvillaea spectabilis Willd.
28/X/70 Scarce (AKG)

Macchiatiella rhami (Boyer de Fonscolombe)

Aloysia triphylla (L'Hér.) Britt.
23/IX/70 Moderate (RJN)
15/XII/71 Moderate (RJN)

Clerodendrum bungei Steud.
3/IV/69 Abundant (RJN)

Dianthus deltoides L.
8/IV/69 Abundant (RJN)

Hagenia abyssinica J. F. Gmel.
6/IV/69 Moderate (RJN)

Hymenanthera dentata R. Br.
18/V/69 Scarce (RJN)

Sagina apetala L.
6/VI/69 Scarce (RJN)

Viola cornuta L.
3/VI/69 Scarce (RJN)

V. odorata L.
21/XI/69 Scarce (RJN)

V. wittrockiana Gams.
13/VI/69 Scarce (RJN)

Viola sp.
9/XI/70 Moderate (RJN)

Macrosiphoniella sanborni (Gillette)

Salvia microphylla HBK
26/III/70 Abundant (RJN)

Macrosiphoniella sp.

Artemisia californica Less.
21/II/70 Scarce (AKG)

Macrosiphum (Sitobion) avenae (Fabricius)

Ampelodesmos mauritanicus (Poir.) T. Durant & Schinz.
18/IV/70 Abundant (AKG)

Bromus carinatus Hook. & Arn.
3/II/70 Moderate (AKG)
3/IV/71 Abundant (CFS)

Oryzopsis miliacea (L.) Benth.
30/IV/69 Moderate (AKG)

Macrosiphum californicum (Clarke)

Salix taxifolia HBK
6/XII/69 Abundant (W-B)

Macrosiphum euphorbiae (Thomas)

Abutilon indicum Sweet
31/III/69 Moderate (AKG)
16/VI/70 Abundant (W-B)

Acacia arabica Willd.
6/VI/69 Moderate (W-B)

Acer tartaricum L.
11/III/70 Moderate (AKG)

Agrimonia eupatoria L.
23/II/70 Scarce (AKG)

Albizia thorelli Pierre
24/III/70 Scarce (W-B)

Alnus tenuifolia Nutt.
18/V/76 Scarce (RLB)

Aloe ciliaris Haw.
18/II/70 Abundant (AKG)

A. immaculata Pillans
23/I/70 Moderate (AKG)

A. wickensii Pole-Evans
27/XIII/69 Moderate (AKG)

Anemopaegma chamberlaynii (Sims) Bur. & K. Schum.
19/VI/70 Moderate (W-B)

Anigozanthos flavidus Redouté
28/XII/70 Scarce (AKG)

Anoda triangularis DC.
25/III/70 Abundant (AKG)

Antigonon leptopus Hook. & Arn.
10/VI/70 Abundant (W-B)

Baccharis glutinosa Pers.
16/II/70 Abundant (W-B)

Berberis triacanthophora Fedde.
27/IV/70 Scarce (AKG)

Brassaia actinophylla Endl.
1/VIII/69 Abundant (W-B)

Bromus carinatus Hook. & Arn.
3/IV/71 Abundant (CFS)

Caesalpinia japonica Sieb. & Zucc.
12/III/70 Abundant (AKG)

Caragana aurantiaca Koehne
12/III/70 Moderate (AKG)

Cassia atomaria L.
17/III/70 Abundant (W-B)

C. bicapsularis L.
17/III/70 Abundant (AKG)

C. mimosoides L.
31/XII/70 Abundant (W-B)

C. nemophila coriacea Symon
15/I/71 Moderate (Kono)

Centranthus ruber DC.
23/II/70 Abundant (W-B)

Chenopodium album Bosc.
17/II/70 Scarce (AKG)

Chorisia insignis HBK
19/II/70 Scarce (AKG)

Cistus incanus L.
6/I/71 Scarce (Kono)

Clematis orientalis L.
19/VI/70 Moderate (W-B)

Clerodendrum nutans Wall.
4/IV/69 Scarce (RJN)

Combretum microphyllum Klotzsch.
13/VI/70 Moderate (AKG)

Convolvulus mauritanicus Boiss.
5/V/70 Scarce (AKG)

Cordia escalyculatha Vell.
21/III/70 Moderate (AKG)

Coreopsis lanceolata L.
28/IV/69 Moderate (AKG)

Crataegus lavallei Herincq
25/IV/70 Abundant (W-B)

Croton megalocarpus Hutchinson
31/III/69 Moderate (AKG)

Dianthus 'China Doll'
12/II/70 Moderate (RJN)

D. deltoides L.
8/IV/69 Abundant (RJN)

Dombeya buettneri K. Schum.
4/I/71 Moderate (Kono)

Duranta repens L.
5/III/70 Moderate (RJN)

D. repens 'Alba'
5/III/70 Abundant (RJN)

D. stenostachya Tod.
18/XII/68 Moderate (RJN)
29/XI/69 Scarce (RJN)
5/III/70 Abundant (RJN)

Echium wildpretii H. Pearson
19/V/69 Scarce Vagrant (VFE)

Eryngium planum L.
5/I/71 Scarce (Kono)

Eucalyptus cladocalyx F. Muell.
21/I/71 Moderate (Kono)

Euonymus japonica Thunb.
27/IV/70 Scarce (AKG)

Ficus iteophylla Miq.
19/III/70 Moderate (W-B)

Ficus sp.
6/I/71 Scarce (Kono)

Filipendula hexapetala Gilib.
5/I/71 Abundant (Kono)

Forsythia 'Lynwood Gold'
6/I/71 Moderate (Kono)

Hagenia abyssinica J. F. Gmel.
6/IV/69 Moderate (RJN)
26/I/70 Abundant (RJN)
16/VI/70 Abundant (RJN)

Hypericum elegans Steph.
5/I/71 Abundant (Kono)

Iris spuria L.
5/I/71 Abundant (Kono)

Lampranthus sp.
14/I/71 Scarce (Kono)

Linum perenne Lam.
1/I/71 Scarce (Kono)

Nandina domestica 'Compacta Nana'
16/IV/69 Moderate (AKG)

Osteospermum ecklonis (DC.) Norlindh.
9/V/69 Scarce (AKG)

Phlomis caucasica K. H. Rechinger
8/IV/69 Abundant (AKG)

Potentilla rupestris L.
5/I/71 Moderate (Kono)

Raphanus sativus L.
8/V/69 Abundant (W-B)

Rhus sylvestris Sieb. & Zucc.
16/III/68 Abundant (AKG)
14/VIII/68 Moderate (W-B)

Rosa banksiae 'Lutea'
5/V/69 Moderate (MBS)

R. hugonis Hemsl.
17/III/71 Abundant (MBS)

R. 'Margo Koster'
22/V/68 Abundant (MBS)

Rosa sp.
29/VI/69 Abundant (MBS)
5/XII/69 Abundant (MBS)
7/III/71 Abundant (MBS)

Rudbeckia hirta L.
29/IX/69 Moderate (W-B)

Rumex crispus L.
12/III/69 Moderate (W-B)

Salvia greggii A. Gray
10/VII/68 Scarce (RJN)
23/I/69 Abundant (RJN)

S. mellifera Greene
21/II/70 (RJN)

S. officinalis L.
16/VII/69 Scarce (RJN)

Schefflera arboricola Hayata
27/III/69 Abundant (W-B)

Senecio adonidifolius Loisel.
5/I/71 Moderate (Kono)

Spathodea campanulata Beauv.
31/III/69 Abundant (W-B)

Stereospermum kunthianum Cham.
15/IX/69 Abundant (W-B)

Teucrium scorodonia L.
23/II/70 Scarce (RJN)

Tulipa gesneriana L.
1/IV/69 Abundant (W-B)

Viola wittrockiana Gams.
13/II/70 Scarce (RJN)

Watsonia sp.
17/V/69 Scarce (AKG)

Withania somnifera Dunal.
5/I/71 Moderate (Kono)

Zinnia elegans 'Wild Cherry'
23/X/69 Scarce (AKG)

Macrosiphum (*Sitobion*) *fragariae* (Walker)

Bromus carinatus Hook. & Arn.
3/IV/71 Abundant (CFS)

Chamaecyparis lawsoniana (A. Murr.) Parl.
10/III/70 Abundant (VFE) (DJV)

Juniperus occidentalis 'Sierra Silver'
10/IV/71 Abundant Vagrant (VFE)

Macrosiphum rosae (L.)

Brunfelsia uniflora (Pohl) D. Don
17/III/70 Moderate (AKG)

Rosa 'American Beauty'
9/III/76 Moderate (MBS)

R. banksiae Ait.
9/III/76 Moderate (MBS)

R. banksiae 'Lutea'
5/V/69 Moderate (MBS)

R. 'Buff Beauty'
9/III/76 Moderate (MBS)

R. 'Glorie Des Mosseux'
21/X/70 Abundant (MBS)

R. 'Cecil Brunner'
9/III/76 Abundant (MBS)

R. hugonis Hemsl.
17/III/71 Abundant (MBS)
R. 'Margo Koster'
22/V/68 Abundant (MBS)
R. 'La France'
9/III/76 Abundant (MBS)
R. 'Manon Cochet'
9/III/76 Abundant (MBS)
R. 'Mme Pierre Oger'
9/III/76 Moderate (MBS)
R. moschata J. Herrm.
9/III/76 Scarce (MBS)
R. moyesii Hemsl. & E. H. Wils.
9/III/76 Scarce (MBS)
R. 'Newport Fairy'
9/III/76 Moderate (MBS)
R. pendulina L.
9/III/76 Scarce (MBS)
R. pisocarpa A. Gray
23/II/71 Abundant (MBS)
9/III/76 Abundant (MBS)
R. 'Sombrevil'
9/III/76 Scarce (MBS)
R. spinosissima L.
10/VII/68 Scarce (MBS)
7/IV/70 Abundant (MBS)
R. rugosa Thunb.
9/III/76 Moderate (MBS)
R. 'Wind Chimes'
9/III/76 Abundant (MBS)
Rosa sp.
7/V/69 Scarce (MBS)
4/XII/69 Abundant (MBS)
7/III/71 Abundant (MBS)
8/III/76 Abundant (MBS)

Macrosiphum sp.
Nephrolepis exaltata (L.) Schott.
27/III/75 Scarce (AGR)
Pinus halepensis Mill.
2/IV/70 Scarce (VFE)
10/IV/71 Scarce (VFE)
Polypodium aureum L.
26/III/69 Moderate (AKG)
Potentilla detommasii Tenore
5/I/71 Moderate (Kono)
Rhamnus crocea Nutt.
20/I/71 Scarce (Kono)
Rosa centifolia L.
20/V/68 Scarce (MBS)
Rosa sp.
4/XII/69 Abundant (MBS)
Senecio mikanioides Otto
21/IV/69 Abundant (W-B)
Sonchus oleraceus L.
6/III/77 Abundant (RLB)
Tulipa sp.
6/III/75 Abundant (RLB)

Masonaphis azaleae (Mason)
Rhododendron sp.
3/III/70 Scarce (W-B)

Masonaphis brevitarsis Gillette and Palmer
Salvia aurea L.
2/VI/69 (RJN)

Masonaphis lambersi MacGillivray
Rhododendron sp.
17/III/69 Moderate (AKG)

Masonaphis morrisoni (Swain)
Actinostrobus pyramidalis Miq.
25/IV/68 Moderate (VFE)
10/II/71 Abundant (VFE)
Araucaria heteophylla (Salisb.) Franco
27/III/70 Scarce (VFE)
Callitris murrayensis Miq.
30/IV/68 Scarce (VFE)
12/III/69 Abundant (VFE)
3/VI/70 Abundant (VFE)
C. propinqua R. Br.
30/V/68 Scarce (VFE)
26/V/69 Moderate (VFE)
20/I/71 Abundant (VFE)
Calocedrus decurrens (Torr.) Florin
24/IV/71 Abundant (VFE)
Calothamnus chrysanthereus F. Muell.
18/VI/70 Moderate (VFE)
Catalpa bignonioides Walt.
15/V/69 Scarce (VFE)
Cedrus deodara (D. Don) G. Don
29/IV/69 Moderate (VFE)
Chamaecyparis lawsoniana (A. Murr.) Parl.
4/VII/69 Moderate (VFE)
C. nootkatensis (D. Don.) Spach
1/VII/69 Moderate (VFE)

C. pisifera 'Cyanoviridis'
26/V/71 Moderate (VFE)

Cistus incanus L.
20/IV/70 Scarce (VFE)

Cryptomeria japonica 'Araucarioides'
22/IV/71 Scarce (VFE)

C. japonica 'Viminalis'
22/IV/71 Moderate (VFE)

Cupressus arizonica Greene
22/VII/69 Scarce (VFE)

C. cashmeriana Royle
21/VI/69 Moderate (VFE)
17/IV/71 Abundant (VFE)

C. forbesii Jeps.
13/III/69 Abundant (VFE)
18/VII/69 Scarce (VFE)
27/III/70 Abundant (VFE)
26/IV/71 Moderate (VFE)

C. guadalupensis S. Wats.
31/III/70 Moderate (DJV)

C. lusitanica Mill.
13/III/69 Scarce (VFE)
24/VII/69 Scarce (VFE)
2/IV/70 Moderate (VFE)
17/IV/71 Abundant (VFE)

C. macnabiana A. Murr.
19/VI/68 Scarce (VFE)

C. pygmaea (Lemm.) Sarg.
3/III/69 Scarce (VFE)
23/XII/69 Scarce (VFE)
1/IV/70 Abundant (VFE)
5/VI/71 Scarce (VFE)

C. sempervirens L.
20/VI/69 Abundant (VFE)

Juniperus bermudiana L.
13/VII/69 Moderate (VFE)
28/IV/71 Abundant (VFE)

J. chinensis 'Blaauw'
19/V/69 Scarce (VFE)
27/V/71 Abundant (VFE)

J. chinensis 'Columnaris Glauca'
21/V/68 Abundant (VFE)
4/V/70 Scarce (VFE)

J. chinensis 'Fruitlandii'
19/V/69 Scarce (VFE)
27/V/71 Moderate (VFE)

J. chinensis 'Hetzii Columnaris'
19/V/69 Scarce (VFE)

J. chinensis 'Hetzii'
19/V/69 Scarce (VFE)
26/V/71 Abundant (VFE)

J. chinensis 'Japonica'
12/VI/71 Moderate (VFE)

J. chinensis 'Keteleeri'
19/V/69 Scarce (VFE)
27/V/71 Abundant (VFE)

J. chinensis 'Pfitzeriana'
21/VI/68 Abundant (VFE)
6/V/69 Abundant (VFE)
19/V/69 Moderate (VFE)
1/V/70 Moderate (VFE)
26/V/71 Scarce (VFE)

J. chinensis 'Robusta Green'
13/VII/69 Scarce (VFE)
26/III/70 Moderate (VFE)
28/IV/71 Abundant (VFE)

J. chinensis 'Sea Green'
26/V/71 Abundant (VFE)

J. chinensis 'Torulosa'
27/V/71 Moderate (VFE)

J. chinensis procumbens 'Aureo-variegata'
26/V/71 Scarce (VFE)

J. monosperma (Engelm.) Sarg.
27/V/71 Abundant (VFE)

J. occidentalis 'Sierra Silver'
10/IV/71 Abundant (VFE)

J. sabina 'Arcadia'
31/V/71 Moderate (VFE)

J. sabina 'Variegata'
27/V/71 Scarce (VFE)

J. scopulorum 'Erecta'
22/VII/69 Scarce (VFE)
10/IV/71 Abundant (VFE)
26/V/71 Abundant (VFE)

J. scopulorum 'Gray Gleam'
31/V/71 Moderate (VFE)

J. scopulorum 'Lakewood Globe'
19/V/69 Scarce (VFE)
31/V/71 Abundant (VFE)

J. scopulorum 'Reptans'
26/V/71 Abundant (VFE)

J. scopulorum 'Steel Blue'
27/V/71 Scarce (VFE)

J. scopulorum 'Table Top Blue'
19/V/69 Moderate (VFE)

J. squamata 'Meyeri'
19/V/69 Moderate (VFE)

J. virginiana 'Cupressiformis'
19/V/69 Scarce (VFE)
11/VII/69 Moderate (VFE)
10/IV/71 Abundant (VFE)
26/V/71 Scarce (VFE)

J. virginiana 'Silver Spreader'
10/IV/71 Moderate (VFE)

Metasequoia glyptostroboides H. H. Hu & Cheng
27/IV/70 Scarce (VFE)

Taxodium mucronatum Ten.
23/IV/70 Scarce (VFE)
22/VI/70 Scarce (VFE)

Thuja occidentalis 'Cristata'
22/VI/69 Moderate (VFE)

Masonaphis sp.

Callitris quadrivalvis Vent.
13/VI/70 Abundant (AKG)

Chamaecyparis lawsoniana (A. Murr.) Parl.
31/III/71 Abundant (VFE)

Cotoneaster frigidus Wall.
24/VI/69 Abundant (AKG)

Cupressus lusitanica 'Pendula'
13/III/69 Moderate (VFE)
31/III/70 Abundant (VFE)
17/III/71 Abundant (VFE)

Juniperus occidentalis 'Sierra Silver'
13/III/70 Moderate (VFE)

J. squamata 'Meyeri'
27/V/71 Abundant (VFE)

Solanum robustum H. Wendl.
15/III/69 Moderate (AKG)

Vitex pseudo-negundo Hand.-Mazz.
7/IV/69 Scarce (AKG)

Melanocallis fumipennellus (Fitch)

Carya illinoinensis (Wangenh.) C. Koch
1/VII/68 Moderate (TLB)
16/VI/69 Abundant (TLB)
8/VII/69 Moderate (TLB)
24/X/69 Scarce (TLB)
5/XI/69 Scarce (TLB)
23/VII/70 Moderate (TLB)
27/VII/70 Moderate (TLB)
3/IX/70 Moderate (TLB)
21/X/70 Abundant (TLB)

Carya ovata (Mill.) C. Koch
28/VIII/70 Scarce (TLB)

Monellia caryella (Fitch)

Carya illinoinensis (Wangenh.) C. Koch
9/X/67 Moderate (TLB)
1/VII/68 Moderate (TLB)
8/VII/69 Moderate (TLB)
21/VIII/69 Scarce (TLB)
13/X/69 Scarce (TLB)
24/X/69 Scarce (TLB)
5/XI/69 Scarce (TLB)
5/XII/69 Scarce (TLB)
23/VII/70 Moderate (TLB)
3/IX/70 Moderate (TLB)
21/X/70 Abundant (TLB)
17/VIII/71 Scarce (TLB)

Monellia costalis (Fitch)

Carya illinoinensis (Wangenh.) C. Koch
1/VII/68 Moderate (TLB)
23/VII/70 Moderate (TLB)
27/VII/70 Moderate (TLB)

Pinus canariensis Sweet
9/XI/70 Moderate Vagrant (VFE)

Monelliopsis bisetosa Richards

Pterocarya fraxinifolia (Lam.) Spach
1/XII/69 Scarce (TLB)

Monelliopsis californica (Essig)

Carya illinoinensis (Wangenh.) C. Koch
9/VI/71 Moderate (TLB)
Juglans californica Wats.
1/VII/68 Moderate (TLB)
10/VI/69 Abundant (TLB)
16/VI/69 Abundant (TLB)
21/VIII/69 Scarce (TLB)
13/X/69 Scarce (TLB)
3/XII/69 Moderate (TLB)
27/IV/70 Moderate (TLB)
1/VII/70 Abundant (TLB)
27/VII/70 Moderate (TLB)
28/VIII/70 Scarce (TLB)
21/X/70 Abundant (TLB)
12/VI/71 Scarce (TLB)

Pterocarya fraxinifolia (Lam.) Spach
29/V/68 Scarce (TLB)
1/XII/69 Scarce (TLB)
3/XII/69 Scarce (TLB)

P. rehderana C. K. Schneider
1/XII/69 Scarce (TLB)

Myzaphis rosarum (Kaltenbach)
  Rosa 'Buff Beauty'
  9/III/76 Moderate (MBS)
  R. 'La France'
  9/III/76 Abundant (MBS)
  R. 'Manon Cochet'
  9/III/76 Abundant (MBS)
  R. 'Mme. Pierre Oger'
  9/III/76 Moderate (MBS)
  R. 'Wind Chimes'
  9/III/76 Abundant (MBS)
  Rosa sp.
  8/III/76 Abundant (MBS)

Myzocallis sp. possibly *castanicola* Baker
  Quercus robur L.
  9/XI/73 Abundant (VFE)

Myzocallis coryli (Goeze)
  Corylus avellana L.
  29/IX/75 Scarce (RLB)
  C. avellana 'Fuscorubra'
  10/VI/69 Abundant (VFE)
  30/VI/70 Abundant (AKG)
  18/IV/71 Moderate (VFE)
  16/XI/71 Abundant (VFE)

Myzocallis punctatus (Monell)
  Ceratonia siliqua L.
  18/III/70 Scarce (AKG)
  Quercus agrifolia Née
  4/III/75 Abundant (RLB)
  Q. engelmannii Greene
  17/I/75 Abundant (RLB)

Myzocallis sp. near *punctatus* (Monell)
  Quercus agrifolia Née
  26/VI/75 Moderate (VFE)
  Q. leucotrichophora A. Camus
  18/VI/73 Scarce (VFE)

Myzocallis walshii (Monell)
  Quercus agrifolia Née
  26/VI/73 Moderate (VFE)

Myzocallis sp.
  Cedrus deodara (D. Don) G. Don
  29/IV/69 Moderate Vagrant (VFE)
  Citharexylum montevidense (Spreng) Moldenke
  18/XII/68 Scarce (RJN)
  Coleonema album E. Mey.
  7/V/70 Moderate Vagrant (W-B)
  Duranta repens 'Alba'
  18/XII/68 Moderate (RJN)
  Rothmannia globosa (Hochst.) Keay
  23/V/75 Scarce Vagrant (RLB)

Myzus ascalonicus Doncaster
  Allium ascalonicum L.
  26/II/70 Abundant (W-B)

Myzus certus (Walker)
  Cerastium tomentosum L.
  13/V/69 Scarce (RJN)
  23/X/69 Abundant (RJN)
  13/II/70 Moderate (RJN)
  3/XI/70 Moderate (RJN)
  Dianthus 'China Doll'
  12/II/70 Moderate (RJN)
  Hymenanthera dentata R. Br.
  28/V/69 Scarce (RJN)
  13/V/70 Moderate (RJN)
  Viola wittrockiana Gams.
  13/II/70 Scarce (RJN)
  Viola sp.
  9/XI/70 Moderate (RJN)

Myzus ornatus Laing
  Agrimonia eupatoria L.
  23/II/70 Scarce (AKG)
  Amygdalus bucharica Korsh.
  20/III/71 Moderate (AKG)
  Bergenia ciliata (Haw.) Sternb.
  3/III/70 Scarce (W-B)
  Caragana aurantiaca Koehne
  12/III/70 Moderate (AKG)
  Centranthus ruber DC.
  23/II/70 Abundant (W-B)
  Cerastium tomentosum L.
  13/V/69 Scarce (RJN)
  13/II/70 Moderate (RJN)
  Dianthus 'China Doll'
  12/II/70 Moderate (RJN)
  Duranta repens L.
  15/V/69 Moderate (RJN)
  18/II/70 Abundant (RJN)
  5/III/70 Moderate (RJN)
  D. repens 'Alba'
  30/XII/69 Moderate (RJN)
  31/XII/70 Moderate (RJN)

D. stenostachya Tod.
18/XII/68 Moderate (RJN)
15/III/69 Moderate (RJN)
30/XII/69 Abundant (RJN)

Echium wildpretii H. Pearson
19/V/69 Scarce Vagrant (VFE)

Ficus iteophylla Miq.
19/III/70 Moderate (W-B)

Nephrolepis exaltata Schott.
27/III/75 Scarce (AKG)

Rosmarinus officinalis 'Prostratus'
13/III/69 Abundant (AKG)

Salvia aurea L.
2/VI/69 Moderate (RJN)

S. greggii A. Gray
10/VII/68 Scarce (RJN)
23/I/69 Abundant (RJN)

S. mellifera Greene
21/II/70 Abundant (RJN)

S. microphylla HBK
21/IV/69 Scarce (RJN)

Sambucus racemosa L.
20/III/69 Moderate (AKG)

Sarcococca saligna (D. Don) Muell.
15/I/69 Scarce (AKG)

Sorbaria tomentosa (Lindl.) Rehd.
15/I/69 Scarce (AKG)

Teucrium chamaedrys L.
22/III/69 Moderate (RJN)

T. fruticans L.
20/XI/69 Scarce (RJN)

T. scorodonia L.
23/II/70 Scarce (RJN)

Thymus serphyllum Coss.
12/VI/68 Moderate (RJN)

Viola odorata L.
21/XI/69 Scarce (RJN)

V. wittrockiana Gams.
13/VI/69 Scarce (RJN)

13/II/70 Scarce (RJN)
25/IV/70 Moderate (RJN)

Myzus persicae (Sulzer)

Abutilon indicum (L.) Sweet
31/III/69 Moderate (AKG)
16/VI/70 Abundant (W-B)

Acer tataricum L.
11/III/70 Moderate (AKG)

Agathis robusta (F. J. Muell.) F. M. Bailey
24/V/69 Scarce (AKG)

Agonis flexuosa Lindl.
5/VI/70 Scarce (AKG)

Agrimonia eupatoria L.
23/II/70 Scarce (AKG)

Ajuga reptans L.
29/V/68 Scarce (RJN)
17/VI/68 Moderate (RJN)

Akebia quinata (Moutt.) Decne.
21/I/70 Abundant (AKG)

Albizia thorelli Pierre
24/III/70 Scarce (W-B)

Aloe ciliaris Haw.
19/II/70 Abundant (AKG)

Aloysia triphylla (L'Hér.) Britt.
8/XII/69 Scarce (RJN)
28/IV/70 Moderate (RJN)

A. virgata Juss.
5/III/70 Abundant (RJN)

Alcea rosea L.
21/II/70 Moderate (AKG)

Althaea setosa Boiss.
28/XII/70 Moderate (W-B)

Amelanchier sanguinea (Pursh.) DC.
19/V/70 Abundant (AKG)
12/XII/70 Abundant (W-B)

Ammi majus L.
22/VI/70 Abundant (W-B)

Amygdalus bucharica Korsh.
20/III/71 Moderate (AKG)

Anemopaegma chamberlaynii (Sims.) Bur. & K. Schum.
19/VI/70 Moderate (W-B)

Anoda triangularis (L.) Schlechtend.
25/III/70 Abundant (AKG)

Antigonon leptopus Hook & Arn.
10/VI/70 Abundant (W-B)

Aphelandra squarrosa Nees
11/II/69 Abundant (AKG)

Aralia chinensis L.
2/II/70 Scarce (AKG)

Aristolochia petersiana Klotzsch.
11/VI/70 Abundant (W-B)

A. tagala Cham.
6/I/71 Abundant (Kono)

Artemisia dracunculus L.
25/II/70 Moderate (AKG)

Asparagus setaceus (Kunth) Jessop
2/VI/69 Scarce (AKG)

A. densiflorus (Kunth) Jessop
8/III/77 Abundant (RLB)

Baccharis vaccinioides Gardn.
11/II/70 Abundant (AKG)

B. glutinosa Pers.
16/II/70 Abundant (W-B)

Baeckea camphorata R. Br.
16/V/70 Moderate (W-B)

Balmea stormae Martinez
31/XII/70 Abundant (AKG)

Barleria obtusa Nees
31/XII/70 Scarce (W-B)

Basanacantha spinosa K. Schum.
14/I/71 Scarce (Kono)

Bocconia frutescens L.
18/IX/70 Abundant (AKG)

Brassaia actinophylla F. Muell.
1/VIII/69 Abundant (W-B)
25/VI/70 Moderate (W-B)

Brassica campestris Oed.
10/II/70 Abundant (AKG)

Brunfelsia uniflora (Pohl.) D. Don
17/III/70 Moderate (AKG)

Buddleia nivea Duthie
5/II/70 Scarce (AKG)

Buettneria urticifolia K. Schum.
19/III/70 Moderate (AKG)

Bulbinella robusta Kunth.
5/III/75 Abundant (RLB)

Buxus sempervirens 'Arborescens'
20/IV/70 Moderate (AKG)

Caesalpinia japonica Sieb. & Zucc.
12/III/70 Abundant (AKG)

Calliandra 'Minima'
9/IV/69 Abundant (AKG)

Candollea tetrandra Lindl.
29/XII/70 Scarce (AKG)

Capsella bursa-pastoris Medic
17/II/70 Abundant (AKG)

Caragana aurantiaca Koehne
12/III/70 Moderate (AKG)

Carum carvi L.
25/VI/70 Abundant (W-B)

Casimiroa edulis Llave
21/VI/70 Scarce (W-B)

Cassia abbreviata D. Oliver subsp. beareana (Holmes) Brenan
7/VI/68 Scarce (VFE)

C. atomaria L.
17/III/70 Abundant (W-B)

C. bicapsularis L.
17/III/70 Abundant (AKG)

C. mimosoides L.
31/XII/70 Abundant (W-B)

C. nemophila coriacea Symon
15/I/71 Moderate (Kono)

Catalpa bignonioides Walt.
15/V/69 Scarce (VFE)

Cecropia peltata L.
14/III/70 Moderate (AKG)

Celtis africana Burm.
5/III/75 Abundant (RLB)

Centranthus ruber DC.
23/II/70 Abundant (W-B)
19/VII/70 Abundant (AKG)

Cerastium tomentosum L.
13/II/70 Moderate (RJN)

Cercidium sonorae Rose & I. M. Johnst.
7/IV/70 Scarce (AKG)

Chamaecyparis nootkatensis (D. Don) Spach
1/VII/69 Moderate Vagrant (VFE)

Chenopodium album Bosc.
17/II/70 Scarce (AKG)

Chlorophytum elatum R. Br.
25/VI/70 Abundant (W-B)

Chomelia obtusa Cham. & Schlect.
16/III/70 Abundant (AKG)

Cistus monspeliensis L.
21/IV/70 Scarce (AKG)

C. incanus L.
6/I/71 Scarce (Kono)

Citharexylum myrianthum Cham.
18/XII/68 Moderate (RJN)
19/VII/69 Scarce (RJN)

Clematis dioica L.
23/I/70 Scarce (W-B)

C. orientalis L.
19/VI/70 Moderate (W-B)

Clerodendrum bungei Steud.
3/IV/69 Abundant (RJN)
10/XI/70 Scarce (RJN)

C. japonicum (Thunb.) Sweet
18/VI/69 Moderate (RJN)

C. myricoides (Hochst.) R. Br.
17/V/69 Scarce (RJN)

C. nutans Wallich.
4/IV/69 Scarce (RJN)
10/XI/70 Scarce (RJN)

C. trichotomum Thunb.
27/VI/69 Moderate (RJN)

Coccoloba sagittifolia Ortega
26/I/70 Scarce (AKG)

Coffea arabica L.
19/V/70 Scarce (AKG)

Coleonema album (Thunb.) Bartl. & H. L. Wendl.
7/V/70 Moderate (W-B)

Cordia cylindristachya Roem. & Schult.
4/I/71 Scarce (Kono)

C. escalyculatha Vell.
21/III/70 Moderate (AKG)

Coronilla varia L.
19/III/69 Scarce (AKG)

Crataegus laevigata 'Paul's Scarlet'
23/V/75 Abundant (RLB)

Croton megalobotrys Muell.
11/VI/70 Abundant (W-B)
Cryptocarya rubra (Mol.) Skeels
16/III/70 Abundant (AKG)

Cucumis sativus L.
17/XII/69 Scarce (AKG)

Cupaniopsis anacardioides (A. Rich.) Radlk.
28/IV/69 Scarce (AKG)

Cuphea hyssopifolia HBK
29/XI/69 Scarce (AKG)

Cydonia sinensis Thovin
17/V/76 Abundant (RLB)

Dianthus deltoides L.
8/IV/69 Abundant (RJN)

Duranta erecta L.
18/XII/68 Moderate (RJN)
15/V/69 Moderate (RJN)
18/II/70 Abundant (RJN)
5/III/70 Moderate (RJN)

D. repens L.
5/III/70 Moderate (RJN)

D. repens 'Alba'
18/XII/68 Moderate (RJN)
3/IV/69 Abundant (RJN)
19/VII/69 Scarce (RJN)
29/XI/69 Scarce (RJN)
30/XII/69 Moderate (RJN)
5/III/70 Abundant (RJN)
31/XII/70 Moderate (RJN)

D. stenostachya Tod.
18/XII/68 Moderate (RJN)
15/III/69 Moderate (RJN)
29/XI/69 Scarce (RJN)
30/XII/69 Abundant (RJN)
5/III/70 Abundant (RJN)

Echium fastuosum Jacq.
5/I/71 Moderate (Kono)

E. wildpretii H. Pearson
19/V/69 Scarce Vagrant (VFE)

Eucalyptus baeuerlenii F. Muell.
25/I/71 Abundant (Kono)

E. caesia Benth.
7/V/70 Abundant (W-B)

E. calophylla R. Br.
20/I/71 Abundant (Kono)

E. cladocalyx F. Muell.
21/I/71 Moderate (Kono)

E. fasiculata Deane & Maiden
25/I/71 Abundant (Kono)

E. punctata DC.
20/I/71 Moderate (Kono)

Ficus iteophylla Miq.
19/III/70 Moderate (W-B)

Ficus sp.
6/I/71 Scarce (Kono)

Hagenia abyssinica J. F. Gmel.
6/IV/69 Moderate (RJN)
26/I/70 Abundant (RJN)

Halimium umbellatum (L.) Spach
5/I/71 Scarce (Kono)

Hibiscus hamabo Sieb. & Zucc.
4/I/71 Abundant (Kono)

Hymenanthera dentata R. Br.
28/V/69 Scarce (RJN)

Hymenosporum flavum (Hook.) F. L. Muell.
4/III/75 Abundant (RLB)
23/V/75 Moderate (RLB)
30/IX/75 Moderate (RLB)

Hypericum elegans Steph.
5/I/71 Abundant (Kono)

H. prolificum L.
5/I/71 Scarce (Kono)

Iris spuria L.
5/I/71 Abundant (Kono)

Juglans californica Wats.
28/II/68 Abundant (TLB)
26/III/68 Abundant (TLB)

Kalanchoe densiflora Rolfe
5/III/75 Abundant (RLB)

Lagerstroemia indica L.
25/IV/70 Scarce (VFE)

Lampranthus sp.
14/I/71 Scarce (Kono)

Malus floribunda Sieb.
30/VI/69 Moderate (AKG)

Messerschmidia fruticosa L.
7/III/77 Scarce (RLB)

Nageliella purpurea (Lindl.) L. O. Williams
16/VI/69 Abundant (AKG)

Nephrolepis exaltata (L.) Schott.
27/III/75 Scarce (AGR)

Odontoglossum cariniferum Rchb.f.
12/IX/69 Abundant (AKG)

Olearia pimeleoides Benth.
17/III/69 Abundant (AKG)

Oncidium ampliatum Lindl.
16/VI/69 Abundant (AKG)

O. cabagrae Schlechter
16/VI/69 Scarce (AKG)

O. sphacelatum Lindl.
16/VI/69 Abundant (AKG)

Oroxylum indicum (L.) Venten.
1/V/69 Abundant (AKG)

Owenia acidula F. Muell.
29/V/69 Scarce (AKG)

Pavonia sepium St.-Hil.
12/VII/69 Moderate (AKG)

Phaedranthus buccinatorium Miers.
19/VI/69 Scarce (AKG)

Philodendron selloum C. Koch
27/III/69 Moderate (AKG)

Phlomis taurica Hartwiss
15/III/69 Scarce (AKG)

Physalis floridana Rydb.
17/XII/69 Scarce (AKG)

Pittosporum illicoides Makino
24/VI/69 Scarce (AKG)

P. mannii Hook.
5/III/75 Abundant (RLB)

Plantago major L.
30/III/71 Abundant (VFE)

Polycarpon tetraphyllum L.
2/V/69 Abundant (RJN)

Portulacaria afra Jacq.
22/IV/69 Abundant (AKG)

Potentilla rupestris L.
5/I/71 Moderate (Kono)

Prostanthera sp.
8/IV/69 Scarce (AKG)

Prunus yedoensis Matsum.
23/VI/69 Scarce (AKG)

Pseudobombax ellipticum (HBK) Dug.
10/XI/70 Moderate (W-B)

Pseudocydonia sinensis C. K. Schneider
5/III/77 Scarce (RLB)

Pterocarya fraxinifolia (Lam.) Spach
5/IV/68 Scarce (TLB)
22/VI/70 Moderate (TLB)
3/IX/70 Scarce (TLB)

P. rehderiana C. K. Schneider
30/III/68 Moderate (TLB)

Puya alpestris C. Gay
9/V/69 Scarce (AKG)

Raphanus sativus L.
8/V/69 Abundant (W-B)

Rhagodia mutans R. Br.
8/IV/69 Scarce (AKG)

Rhus sylvestris Sieb. & Zucc.
14/VIII/68 Moderate (W-B)
19/VI/69 Scarce (AKG)

Ricinus communis L.
20/V/69 Moderate (AKG)

Rosa banksiae Ait.
24/IV/70 Scarce (MBS)

Rumex crispus L.
12/III/69 Moderate (W-B)

Ruttya fruticosa Lindau.
16/V/69 Scarce (AKG)

Sagina apetala L.
6/VI/69 Scarce (RJN)

Salsola iberica Sennen & Pau.
9/V/69 Moderate (W-B)

Salvia aurea L.
2/VI/69 Moderate (RJN)

S. greggii A. Gray
10/VII/68 Scarce (RJN)
23/I/69 Abundant (RJN)
5/III/77 Scarce (RLB)

S. mellifera Greene
21/II/70 Abundant (RJN)

S. microphylla HBK
21/IV/69 Scarce (RJN)
26/III/70 Abundant (RJN)

S. nutans L.
21/XI/69 Moderate (RJN)

S. pratensis L.
16/IX/69 Moderate (RJN)

Sambucus mexicana Presl.
21/III/70 Abundant (AKG)

S. nigra L.
8/VII/69 Scarce (AKG)

Santolina virens Mill.
17/IV/69 Scarce (W-B)

Sarcococca saligna (D. Don) Muell
15/I/69 Scarce (AKG)
21/VI/69 Moderate (W-B)

Schinus polygamus 'Cabrera'
18/VII/69 Scarce (AKG)

Senecio adonidifolius Loisel.
5/I/71 Moderate (Kono)

Sida rhombifolia L.
1/VIII/69 Scarce (W-B)

Solanum hispidum Pers.
4/IV/69 Moderate (AKG)

S. seaforthianum Andr.
31/III/69 Abundant (AKG)

Sterculia caudata Heward
1/VIII/69 Moderate (W-B)

Stereospermum kunthianum Cham.
15/IX/69 Abundant (W-B)

Strongylodon macrobotrys A. Gray
16/IX/69 Abundant (AKG)

Tagetes patula L.
5/V/69 Moderate (AKG)

Tecoma fulva G. Don
1/V/69 Abundant (W-B)

Teucrium chamaedrys L.
22/III/69 Moderate (RJN)

T. flavum L.
23/XII/69 Scarce (RJN)

T. scorodonia L.
23/II/70 Scarce (RJN)

Tibouchina multiflora (G. Gardn.) Cogn.
31/III/69 Moderate (AKG)

Tilia amurensis Komarov.
3/IV/69 Scarce (AKG)

Tithonia rotundifolia (Mill.) S. F. Blake
1/VIII/69 Scarce (W-B)

Tubocapsicum anomalum Makino
1/V/69 Abundant (AKG)

Verbena carolina L.
16/IX/69 Abundant (AKG)

Veronica perfoliata R. Br.
4/III/75 Abundant (RLB)

Vinca minor L.
22/III/69 Scarce (AKG)

Viola wittrockiana Gams.
13/VI/69 Scarce (RJN)
13/II/70 Scarce (RJN)
25/IV/70 Moderate (RJN)

V. wittrockiana 'Majestic Giant'
4/XI/70 Abundant (RJN)

Vitex negundo L.
21/VI/69 Abundant (AKG)

V. pseudo-negundo Hand.-Mazz.
7/IV/69 Scarce (AKG)

Viola sp.
9/XI/70 Moderate (RJN)

Withania riebeckii Schweinf.
16/IX/69 Scarce (AKG)

Zexmenia frutescens Blake
16/IX/69 Moderate (AKG)

Myzus sp.
Hymenosporum flavum F. Muell
20/I/75 Abundant (RLB)

Neophyllaphis podocarpi Takahashi
Podocarpus macrophyllus (Thunb.) D. Don
1/V/69 Abundant (VFE)
2/X/69 Abundant (VFE)
14/IV/70 Abundant (VFE)
22/VI/70 Moderate (VFE)
13/II/71 Moderate (VFE)
31/V/71 Abundant (VFE)

Neotoxoptera oliveri (Essig)
Allum schoenoprasum L.
24/VI/70 Abundant (AKG)
A. tuberosum Rottl.
25/II/70 Abundant (AKG)

Neotoxoptera violae (Pergande)
Cerastium tomentosum L.
13/V/69 Scarce (RJN)
23/X/69 Abundant (RJN)
13/II/70 Moderate (RJN)
5/XI/70 Moderate (RJN)
Dianthus deltoides L.
8/IV/69 Abundant (RJN)
Hymenanthera dentata R. Br.
18/V/69 Scarce (RJN)
Teucrium chamaedrys L.
22/III/69 Moderate (RJN)
Viola odorata L.
21/XI/69 Scarce (RJN)

Ovatus crataegarius (Walker)
Teucrium fruticans L.
22/VII/68 Scarce (RJN)

Ovatus phloxae (Sampson)
Cerastium tomentosum L.
13/V/69 Scarce (RJN)

Periphyllus negundinis (Thomas)
Acer negundo L.
27/IV/70 Abundant (W-B)

Pleotrichophorus glandulosus (Kaltenbach)
Artemisia nutans Willd.
22/V/67 Abundant (MDL)

Prociphilus fraxinifolii (Riley)
Fraxinus uhdei 'Majestic Beauty'
23/V/75 Moderate (RLB)

Pterocallis alni (de Geer)
Alnus arguta Benth.
18/V/76 Scarce (RLB)
A. rhombifolia Nutt.
17/V/76 Scarce (RLB)
A. tenuifolia Nutt.
18/V/76 Scarce (RLB)

Pterocallis sp.
Alnus formosana Makino
4/III/77 Scarce (RLB)

Rhopalosiphum fitchii (Sanderson)
Bromus carinatus Hook. & Arn.
5/II/70 Moderate (AKG)

Rhopalosiphum insertum (Walker) group
Poa annua L.
7/III/77 Scarce (RLB)

Rhopalosiphum maidis (Fitch)
Bromus carinatus Hook. & Arn.
5/II/70 Moderate (AKG)
Echinochloa crus-gallis (L.) Beauv.
14/I/71 Abundant (CFS)
Oryzopsis miliaceae Benth. & Hook.
30/IV/69 Moderate (AKG)
Sida rhombifolia L.
1/VIII/69 Scarce (W-B)
Sorghum halepense (L.) Pers.
5/VI/69 Abundant (W-B)
8/VII/69 Abundant (AKG)
S. bicolor (L.) Moench
16/X/69 Abundant (AKG)
5/III/77 Abundant (RLB)

Rhopalosiphum padi (L.)
Bromus carinatus Hook. & Arn.
8/IV/70 Moderate (CFS)
9/V/70 Abundant (CFS)
3/IV/71 Moderate (CFS)
Chamaecyparis lawsoniana (A. Murr.) Parl.
10/III/70 Abundant (VFE)
Cupressus lusitanica Mill.
17/IV/71 Abundant Vagrant (VFE)
Oryzopsis miliacea Benth. & Hook.
30/IV/69 Moderate (AKG)

Rhopalosiphum rufiabdominalis (Sasaki)
Conyza bonariensis (L.) Cronq.
17/X/73 Moderate (CFS)

Echinochloa crus-galli (L.) Beauv.
5/VI/73 Abundant (CFS)

Rhopalosiphum sp.

Rosa spinosissima L.
10/VII/68 Scarce (MBS)

Tecoma fulva G. Don
1/V/69 Abundant (W-B)

Schizolachnus curvispinosus Hottes, Essig and Knowlton

Pinus durangensis Roezl.
22/IV/71 Moderate (VFE)

P. glabra Walt.
11/XI/69 Abundant (VFE) (DJV)

P. roxburghii Sarg.
5/III/70 Abundant (VFE)

Siphonatrophia cupressi (Swain)

Cupressus lusitanica Mill.
7/XI/69 Scarce (VFE)
2/IV/70 Moderate (VFE)
26/IV/71 Abundant (VFE)

C. pygmea Sarg.
1/IV/70 Abundant (VFE)

C. sempervirens 'Stricta'
25/IV/70 Scarce (VFE)

Ervatamia coronaria Stapf.
12/XI/70 Abundant (VFE)

Smynthurodes betae Westwood

Portulaca oleracea L.
2/X/72 Abundant (CFS)

Stegophylla essigi Hille Ris Lambers

Quercus agrifolia Née
29/VI/73 Abundant (VFE)
4/III/75 Abundant (RLB)

Takecallis arundicolens (Clarke)

Arundinaria simonii (Carrière) A. & C. Rivière
6/XII/69 Abundant (MDL)

Pseudosasa japonica Makino
23/IV/70 Abundant (MDL)

Sasa pygmaea Mitf.
28/I/70 Abundant (MDL)

Takecallis arundinariae (Essig)

Arundinaria amabilis McClure
7/II/68 Moderate (MDL)
13/IV/70 Moderate (MDL)

A. simonii (Carrière) A. & C. Rivière
15/IV/70 Scarce (MDL)

Bambusa glaucescens 'Stripestem Fernleaf'
15/IV/70 Scarce (MDL)

B. oldhamii Munro
6/XII/69 Abundant (MDL)

Bambusa sp.
23/II/68 Abundant (MDL)

Chimonobambusa hookerianum Nakai
13/IV/70 Scarce (MDL)

C. marmorea (Mitt.) Nakino
13/IV/70 Scarce (MDL)

Phyllostachys aurea Carrière
6/XII/69 Abundant (MDL)
27/I/70 Abundant (MDL)
20/I/75 Abundant (RLB)

P. bambusoides Sieb. & Zucc.
13/IV/70 Moderate (MDL)

P. bambusoides 'Castillon'
7/II/68 Abundant (MDL)

P. flexuosa A. & C. Rivière
7/II/68 Abundant (MDL)

P. meyeri McClure
20/I/68 Abundant (MDL)
13/IV/70 Moderate (MDL)

P. nigra (Lodd.) Munro
6/XII/69 Moderate (MDL)

P. nigra 'Henon'
6/XII/69 Scarce (MDL)

P. viridis (R. A. Young) McClure
7/II/68 Abundant (MDL)
13/IV/70 Scarce (MDL)

Phyllostachys sp.
6/XII/69 Abundant (MDL)
10/X/70 Abundant (MDL)
6/XII/69 Moderate (MDL)
15/IV/70 Moderate (MDL)

Pleioblastus simoni Nakai
16/IV/70 Scarce (MDL)

Semiarundinaria fastuosa (Marliac) Makino
15/IV/70 Scarce (MDL)

Tinocallis platani (Kaltenbach)

Metrosideros kermadecensis W. Oliver
15/I/71 Moderate (Kono)

Tinocallis ulmifolii (Monell)

Carya illinoinensis (Wangenh.) C. Koch.
27/VII/70 Moderate (TLB)

Toxoptera aurantii (Boyer de Fonscolombe)

Acer cappadocicum Gled.
17/VII/70 Scarce (AKG)

Agonis flexuosa (K. Spreng.) Schauer.
5/VI/70 Scarce (AKG)

Camellia fraterna Hance
22/IX/70 Scarce (AKG)

C. granthamiana Sealy
21/IX/70 Scarce (W-B)

Camellia sp.
1/X/75 Scarce (RLB)

Clausena lansium (Lour.) Skeels
27/III/70 Scarce (AKG)

Clematis armandii Franch
2/XI/70 Scarce (AKG)

Cordia superba Cham.
30/IX/70 Abundant (AKG)

Murraya paniculata (L.) Jack
7/X/76 Moderate (RLB)

Olearia argophylla F. Muell
20/I/71 Moderate (Kono)

Quillaja saponaria Molina
29/X/69 Scarce (AKG)

Rhamnus californica Eschsch.
10/III/70 Abundant (W-B)

Xylosma congestum (Lour.) Merrill
23/VI/69 Scarce (AKG)
18/XI/68 Abundant (W-B)

Tuberculatus (*Pacificallis*) *columbiae* Richards

Quercus bebbiana C. K. Schneid.
18/IV/73 Scarce (VFE)

Tuberculatus (*Pacificallis*) sp. near *columbiae* Richards

Quercus alba L.
12/XI/73 Moderate (VFE)

Q. agricolia Née
26/VI/73 Moderate (VFE)

Q. emoryi Torr.
13/VI/73 Scarce (VFE)

Q. ganderi C. Wolf
18/VI/73 Moderate (VFE)

Q. leucotrichophora A. Camus
18/VI/73 Scarce (VFE)

Tuberculatus (*Pacificallis*) *maureri* (Swain)

Quercus agrifolia Née
26/VI/73 Moderate (VFE)
29/VI/73 Abundant (VFE)

Tuberculatus (*Tuberculoides*) *annulatus* (Hartig)

Quercus robur L.
9/VII/73 Abundant (VFE)
1/XI/73 Abundant (VFE)
8/VI/75 Abundant (RLB)

Tuberolachnus salignus (Gmelin)

Carpenteria californica Torr.
30/I/70 Moderate (AKG)

Salix taxifolia HBK
6/XII/69 Abundant (W-B)

Wahlgreniella nervata (Gillette)

Rosa hugonis Hemsl.
17/III/71 Abundant (MBS)

R. 'Manon Cochet'
9/III/76 Abundant (MBS)

R. pisocarpa A. Gray
23/II/71 Abundant (MBS)

Rosa sp.
29/VI/69 Abundant (MBS)

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(HGW) 610 Rose Marie Drive, Arcadia, California 91006; (MBS) Systematic Entomology Laboratory, IIBIII, Fed. Res., Sci. & Educ. Admin., USDA, Beltsville, Maryland 20705; and (LE) Los Angeles State and County Arboretum, 301 North Baldwin Avenue, Arcadia, California 91006.

PROC. ENTOMOL. SOC. WASH.
80(4), 1978, pp. 606–610

A NEW GENUS, SPECIES AND FAMILY OF HYMENOPTERA (ICHNEUMONOIDEA) FROM CHILE

W. R. M. Mason

Abstract.—*Apozyx penyai*, a new genus and species, is described from the temperate forest of Arauco province, Chile. The species has a mixture of features of Ichneumonidae, Braconidae and Agriotypidae. It represents a new family, Apozygidae.

A single male specimen, superficially resembling a *Spathius* (Braconidae) with a second recurrent vein, collected by Luis E. Peña in Chile has long stood in the Canadian National Collection. I delayed description in the hope of obtaining more specimens, especially to discover the characteristics of the female; but now, after almost 20 years of waiting and examining at least 20,000 Ichneumonoidea from Chile, I am convinced that the species must be so rare that further delay is unjustifiable. I think it best to describe this strange creature in hope that the publication will stimulate those with opportunity to make an effort to find more specimens.

Apozyx penyai Mason, new genus and new species

This description is to cover genus and species. It seems pointless to guess at the heirarchical levels appropriate to the various characters on the basis of one specimen.

Etymology.—The generic name is a Greek masculine noun[1] meaning bachelor. The spelling of the specific patronym, because the diacritic "ñ" is not allowed by the Code (Art. 27), is modified to produce the approximately correct pronounciation by most European language speakers.

Description.—Head subcuboid, sparsely hairy, and generally shiny (Figs. 1–4); mandibles stout and short but strongly tapered, (Figs. 3 and 4) upper tooth larger than lower; maxillary palpi with 5 articles, the most proximal 2 apparently fused; labial palpi with 4 subequal thickened articles; clypeus with a very prominent transverse ridge, the apical part strongly receding (Figs. 3 and 5), apical margin concave; labrum polished and concave, filling cavity between mandibles and clypeus, mouth thus resembling that of a cyclostome braconid but opening lenticular, about 2× as wide as long (Fig. 4); antennae unspecialized (Fig. 9), flagellum 16-jointed, articles 2–4× longer than wide and bearing longitudinal placodes; ocelli round and small (Fig. 2); occipital carina complete, joining hypostomal well above mandible base.

Thorax (Figs. 1, 2 and 7). Pronotal structure typical of Ichneumonoidea, that is, 2 triangular sides connected by a narrow transverse collar and posterior corners touching tegulae and fore coxae; propleuron with a small lobe overlapping pronotum at lower corner; notauli deep, crenulate, and extending back to meet just before scutellum (Fig. 2); median lobe of scutum broadly concave medially and strongly elevated laterally at notauli where the scutum turns down from horizontal to vertical; scutellum apically weakly striate and bearing a low median carina on the apical declivity (Fig. 2); mesopleuron with complete prepectal carina and mesulcus but without sternauli (Fig. 1); propodeum (Figs. 1 and 7) long and areolated, with conspicuous apophyses and a strongly marked declivity behind them; pronotum, metapleuron and propodeum mostly rugose, balance of thorax smooth and sparsely hairy.

Legs with divided trochanters; tibial spurs short, 1: 2: 2; tarsal claws simple; fore tibia with dense multiple rows of thickened hairs on outer anterior side; middle tibia with a similar but weaker armature; remainder of legs shiny and sparsely hairy except for dense hair on inner apical part of all tibiae and on the tarsi. Hind coxae and abdomen arising from 3 separate foramina on the thorax and propodeum.

Wings (Fig. 8) with venation most similar to Braconidae but the forewing with a strong 2nd recurrent; hindwing with a short, but sclerotized discoidella and no trace of brachiella; 3 hamuli on metacarpella; basella meeting subcostella proximad to radiella; no trace of anal lobe.

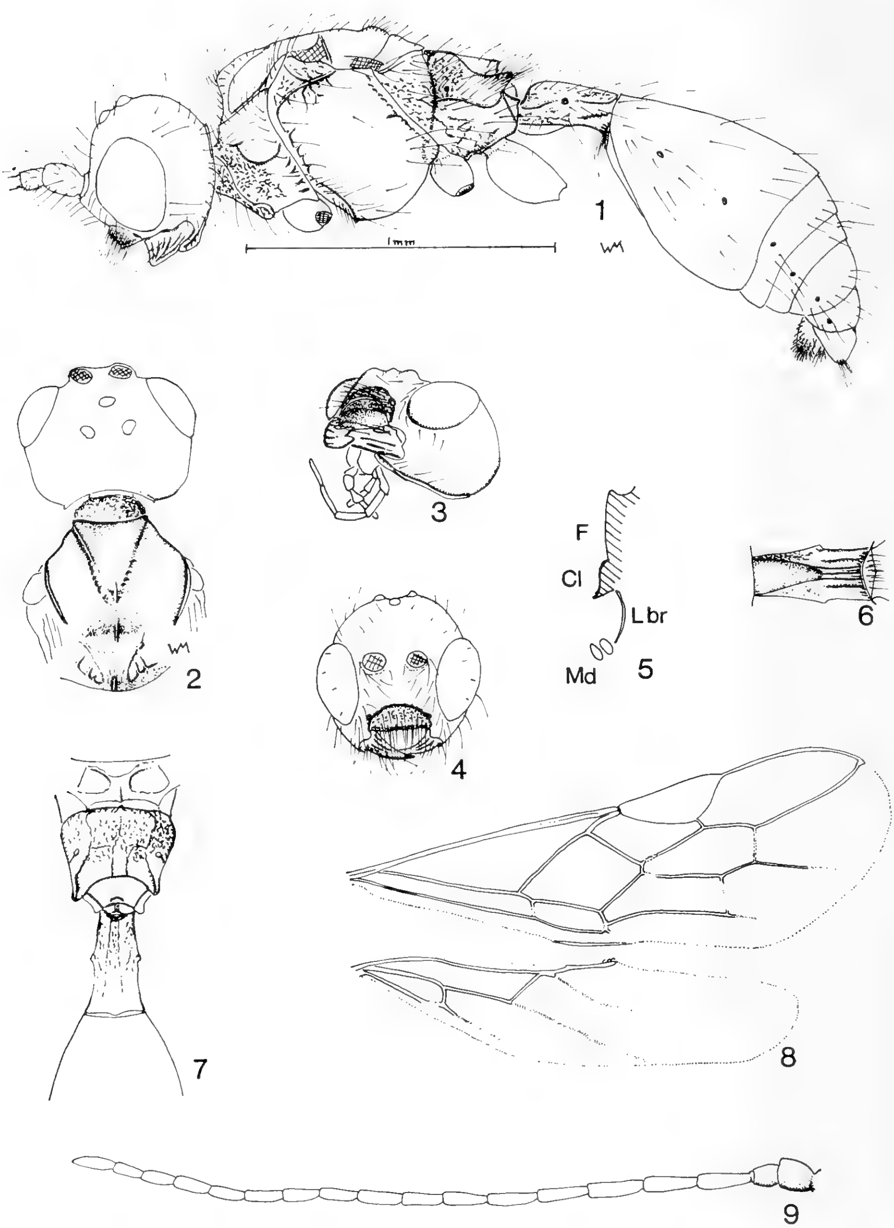
Abdomen with tergum I and sternum I solidly fused into a rigid, rugose, tubular petiole (Figs. 1, 6 and 7); sternum I smooth and visible only beneath anterior ½ of petiole; petiolar segment truncate posteriorly, thus the sternal and tergal regions equally long; sides of tergum I apparently [Without dissection it is impossible to decide whether the sternite ends near the middle or extends narrowly to the posterior end of the first segment.] meeting along midventral line of posterior ½ of petiole (Fig. 6); a lunule of soft integument present at base of sternum II. Remainder of abdomen (Fig. 1), both terga and sterna sclerotized, smooth, sparsely hairy and evenly convex; terga II and III fused and very large; sterna overlapping and not fused; more posterior terga and sterna freely articulated and somewhat telescoped; hypopygium small, apically emarginate and simple; parameres simple, balance of genitalia difficult to observe; pygostoles present, a little longer than wide.

Female unknown.

Holotype.—♂, Pichinahuel, Cordillera Nahuelbuta, Arauco, CHILE, 10–20 Jan. 1959, Luis E. Peña. CNC No. 15523.

Discussion

Although the affinities of *Apozyx* could be more confidently assessed with a knowledge of the female and larval anatomy and the life history, there is enough evidence in the male to show that it fits best in the



Figs. 1–9. *Apozyx penyai.* 1, Lateral whole view. 2, Head to scutellum, dorsal. 3, Head, lateroventral. 4, Head, anterior. 5, Theoretical median longitudinal section of head to show arrangement of face (F), clypeus (Cl), labrum (Lbr) and mandibles (Md). 6, Ventral side of petiole, anterior end to left. 7, Metanotum, propodeum and petiole, dorsal. 8, Wings (scale ⅔ as large as other figures). 9, Antenna.

Ichneumonoidea. The following features are significant for this placement: 1, antennae not elbowed, i.e., the scape short; 2, flagellum with 16 articles; 3, flagellar articles with longitudinal placodes; 4, mandibles with two apical teeth; 5, trochanters double; 6, costa and subcosta of forewing fused; 7, large pterostigma present; 8, no anal lobe in hindwing; 9, copius venation with two closed cells in hindwing; 10, true abdomen with 9 distinct segments; and 11, spiracles on each tergum from 1 to 8.

The hindwing venation is of the braconid type because of the presence of a basellan vein (2r-m) and absence of an intercubitella (3r-m). The forewing is braconid-like because of the large 2nd cubital cell (1Rs) and basal abscissa of cubitus (Rs+M) but the 2nd recurrent (2m-cu) vein is never found in braconids (except rarely in freaks).

The abdomen suggests the Agriotypidae by its fused second and third terga, by its convex and strongly sclerotized sterna and by the fused and tubular petiole.

The petiolar structure is significant. In all generalized Ichneumonidae and Braconidae the petiolar sternum is separate and divided into a rigidly sclerotized anterior part and a partly membranous posterior part that may bear one or two weakly sclerotized plates. Even in specialized groups where the elements are fused, the posterior part of the sternite is never as long as the tergite and always leaves a V- or U-shaped membranous area at the ventral apex. In most Chalcidoidea, Cynipoidea, large parts of the Proctotrupoidea and in Agriotypidae and Evaniidae the petiolar tergite and sternite are fused into a tubular or ring-like structure, whose ventral surface is about equal to the dorsal, so that there is no apical ventral membranous area. This is the type of petiole found in *Apozyx*. It raises the possibility that *Apozyx* may really be related to unknown, and presumably more fully veined, ancestors of some microhymenopterous group. However the possibility is so speculative that I think it better at present to place *Apozyx* in Ichneumonoidea where most its characters are harmonious. It will be difficult to place it confidently until there is far better knowledge of *Apozyx* and of phylogeny of Apocrita.

Nevertheless a placement must be made. The genus can be forced into existing families only by a procrustean redefinition of family characters that I find unacceptable. I place this genus in a new family, Apozygidae, assigned provisionally to Ichneumonoidea.

Family Characters

Apozygidae.—Mandible 2-toothed; antennal flagellum with more than 14 articles; trochanters divided. Wings present and with generalized venation; forewing with costa and subcosta fused; stigma large; basal abscissa of cubitus (Rs+M) present; 2nd cubital cell (1Rs) large; 2nd recurrent (2m-cu) present. Hind wing with 2 closed cells; basellan vein

(2r-m) meeting subcosta before radius; intercubitella (3r-m) absent. Petiole tubular and with components completely fused, ventrally with no membranous area; sternum II and following fully sclerotized and evenly convex when dry; metasomal spiracles 1–7 all present and approximately equal sized.

Biosystematics Research Institute, Agriculture Canada, Ottawa, Canada, K1A 0C6.

Footnote

[1] *Apozyx* is not found in most Greek dictionaries because it was used only by one Eustathius in the 12th century.—Editor's note (G. C. Steyskal).

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80(4), 1978, pp. 611–615

NOTES ON NATHAN BANKS' SPECIES OF THE MITE GENUS *CARABODES* (ACARI: ORIBATEI)

Roy A. Norton

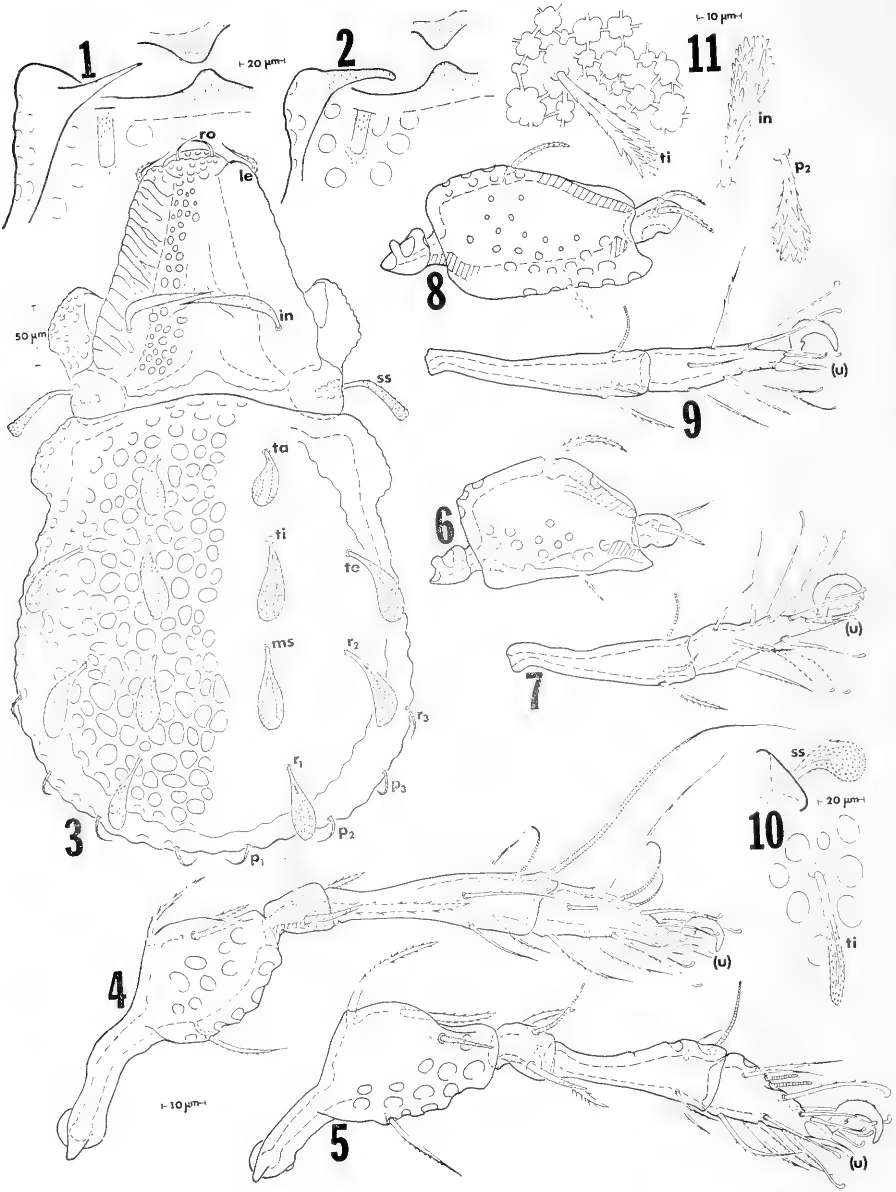
Abstract.—The identity and taxonomic status of six mite species described by Banks in the genus *Carabodes* is discussed. A lectotype is selected for *C. dorsalis* Banks, and *C. omo* (Jacot) is designated a junior subjective synonym of *C. granulatus* Banks.

Primarily during the period 1894–1915, the arthropodologist Nathan Banks described more than 100 species of oribatid mites; most of these were from eastern North America. The general quality of his descriptions was low by modern standards, which, in conjunction with the trend in later years toward narrowing generic concepts, necessitates reexamination of his species. This has been done in a few instances by subsequent oribatologists, but most are still in need of redescription and generic recombination. The purpose of this note is to examine the identity and taxonomic status of the six species placed by Banks (1895a, 1895b, 1896) in the genus *Carabodes* C. L. Koch. I wish to thank Drs. Herbert W. Levi (Cambridge, Massachusetts) and E. W. Baker (Beltsville, Maryland) for providing access to Banks' type-specimens in the Museum of Comparative Zoology (MCZ) and U.S. National Museum (USNM) collections, respectively.

Carabodes apicalis Banks and *Carabodes dorsalis* Banks

Two of Banks' six "*Carabodes*" species are not members of the Carabodidae. Jacot (1937) transferred Banks' (1895a) species *C. apicalis* to *Carabodoides* when the genus was first proposed; it is in need of redescription. Most recently, this genus has been placed in the family Anderemaeidae (Balogh, 1972).

The second species, *Carabodes dorsalis* Banks, 1896, was correctly transferred to *Nanhermannia* Berlese (family Nanhermanniidae) by Jacot (1937). Three specimens are located in the MCZ; two are labeled "cotype" and mounted in balsam on separate slides, one is in alcohol and is the "suspected type" according to unpublished MCZ listings. A problem exists because one of the two slide-mounted specimens (the ventral mount) is not this species; it appears conspecific with *Carabodes brevis* Banks. It has obviously been remounted since its deposition, but there is no record of who mounted or labeled the specimen. The second slide (a lateral mount) bears a correctly identified specimen; it is labeled a "cotype" in



Figs. 1–2. *Odontocepheus elongatus.* 1, Left humeral region of specimen from England. 2, Left humeral region of specimen from New York. Figs. 3–9. *Carabodes niger.* 3, Dorsal aspect (legs removed). 4, Leg I. 5, Leg II. 6, Femur and genu of leg III. 7, Tibia and tarsus of leg III. 8, Femur and genu of leg IV. 9, Tibia and tarsus of leg IV. Fig. 10. *Carabodes brevis,* sensillus (*ss*) and notogastral seta *ti* of cotype. Fig. 11. *Carabodes granulatus,* prodorsal seta *in* and notogastral setae *ti* (with integumental sculpturing) and p_2.

A. P. Jacot's handwriting and was probably originally mounted from alcohol by him. The alcoholic specimen still carries a label in Banks' handwriting. I hereby designate the single alcoholic specimen as the lectotype of *Carabodes dorsalis* Banks and the laterally mounted "cotype" as a paralectotype. Species concepts in *Nanhermannia* have not improved since Hammen's (1959) clarification of the identity of the type-species, *N. nana* (Nicolet). Questions raised by Jacot (1937) and Hammen (1959) on the synonymy of Banks' species with species described from Europe will have to be answered by population studies, not simply redescription of type-specimens.

Carabodes oblongus Banks

Banks himself (1895a) was the first to indicate the need for the removal of this species from *Carabodes*, but its present genus, *Odontocepheus* Berlese, had been proposed for half a century before Johnston (1965) effected the recombination. I have examined specimens of the type-species of *Odontocepheus*, *O. elongatus* (Michael), from England and Scandinavia and compared them with the type-specimen of *O. oblongus* (MCZ) and a number of other specimens from the northeastern U.S. The size range of the American mites (505–610 μm) spans the measurements of my European specimens, and there are only two notable differences. The notogastral setae are relatively slightly shorter in the American specimens; setae of the series h_3, ps_3, ps_2, and ps_1, for example, do not extend posteriorly as far as the insertion of the next seta. Also, the spine-like apophysis which extends medially from the humeral region of the notogaster is shaped differently in the American specimens (Figs. 1 and 2).

My European material is limited, however; and considering the variation attributed to body length and setal shapes noted in European populations by Perez-Iñigo (1971), his synonymy of *O. oblongus* with *O. elongatus* (apparently without the benefit of seeing American specimens) seems justified on morphological grounds.

Carabodes niger Banks

This and the following two species are true members of the genus *Carabodes*, as it is conceived at this time. *Carabodes niger* is one of the largest species in the northeast. Banks' (1895a) original estimate of 0.5 mm is misleading; 17 cotypes in the MCZ and USNM collections ranged from 490–643 μm, total length (mean 580 μm). Most collections from New York and Ohio have been from fungal fruiting bodies (especially *Polyporus* spp.), but I have collected it from forest leaf litter in North Carolina. The following is presented as a more complete diagnosis of the species.

Integument strongly sculptured (Fig. 3), mostly with pit-like depressions

8–25 μm in diameter. Prodorsum with weak pitting and "V" shaped ridge between lamellae; lamellae mostly with transverse ridges instead of pits. Dorsosejugal groove deep, broad (cervical cavity of Sellnick and Forsslund, 1953). Seta *ro* smooth, attenuate; *le* flattened, acuminate, with small barbs; *in* lanceolate, flattened, dorsally covered with small barbs, tips usually crossing medially. Sensillus (*ss*) distally spatulate, with ventrally deflexed sides; dorsal surface with small barbs. Notogaster with distinct postero-lateral rim. Setae *ta*, *ti*, *te*, *ms*, r_1 and r_2 large, flattened, spatulate, 2.9–3.2 times longer than broad, dorsally covered with small barbs except along medial axis. Setae r_3, p_1, p_2 and p_3 setiform, with small barbs. Legs as in Figs. 4–9.

In the Barneby Center, Ohio population studied, setae r_3, p_1, p_2 and p_3 are somewhat longer, almost reaching the insertion of the next posterior seta. Also, the unguinal setae (*u*) of all tarsi are simply scale-like, lacking the distal attenuation present in the cotypes from Long Island.

The specific epithet *nigra* was used in the original description, but since *Carabodes* is a masculine noun, it was later emended to *niger* (Banks, 1904).

Carabodes brevis Banks

The holotype (labeled "type") is mounted in balsam and located in the MCZ, along with an alcoholic "cotype." As mentioned previously, the misidentified cotype of *Carabodes dorsalis* belongs to this species and may be a member of the original type-series which was wrongly labeled in later years.

This species is generally similar to *C. niger*, but the sensillus is short, strongly clavate and the central notogastral setae are much thinner, only slightly broadened distally (Fig. 10). Seta *in* is similar to that of *C. niger*, but slightly narrower. Setae r_3, p_1, p_2 and p_3 are slightly smaller than the central dorsal setae, but there is no strong dimorphism as in *C. niger*. The dorsosejugal groove is shallower (there is no cervical cavity) and the medial prodorsal ridge is absent. All three specimens in the MCZ are about 500 μm in length; Banks' (1896) original statement of 0.4 mm is erroneous.

Carabodes granulatus Banks

A single alcoholic specimen, the holotype, is located in the MCZ. This species can be distinguished from all other known American *Carabodes* species by means of the clavate, coarsely barbed notogastral and interlamellar setae, and the integumental sculpturing of the notogaster which gives the impression of small, interconnected "rosettes" (Fig. 11).

Examination of several cotypes of *Carabodes omo* Jacot (1937:241) from the USNM showed this to be a junior subjective synonym of *C. granulatus* (*new synonymy*). The species is common in sphagnum bogs in the northeastern U.S. and forest litter in North Carolina.

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S.U.N.Y. College of Environmental Science and Forestry, Syracuse, New York 13210.

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REARING OF TEXAS TABANIDAE (DIPTERA). I. COLLECTION, FEEDING, AND MAINTENANCE OF COASTAL MARSH SPECIES

Patrick H. Thompson and Peter C. Krauter

Abstract.—In order to study methods of rearing, 1639 females of several species of coastal marsh Tabanidae were collected in modified Manitoba Traps and in modified Animal Traps, augmented with CO_2 from dry ice, at West Galveston Bay, Texas; five weekly collections from 18 July–17 August, inclusive, produced the following totals of dominant species: *Tabanus nigrovittatus* Macquart, 1228; *T. lineola* var. *hinellus* Philip, 349; and *T. acutus* (Bigot), 62. Immediately after their collection, many females fed on warmed, citrated beef blood which was held in prophylactics derived from animal membranes. From 26.7–39.6% of 353 females of the three species engorged to repletion on prophylactics placed on top of trap collection containers. Survivorship curves for one sample population showed that mortality rates were fairly constant at all age levels for these three species; 50% and 0% survivorships, respectively, occurred at 5 days and 50 days for *T. nigrovittatus*; 4 days and 36 days, *T. lineola* var. *hinellus*; and 9 days and 49 days, *T. acutus*. Comparison of collection dates of minor species, with that from a study made in 1971, indicated that several inland species had greatly declined or disappeared in the 6-year interim between 1971 and 1977.

Study of Tabanidae within the laboratory has been impeded by negative results in rearing these insects. To the present day, scientists throughout the world have attempted to maintain and to perpetuate many species, mostly with refractory results. According to these researchers, major hurdles to such success with tabanids have been caused by the reluctance of these insects to accept blood; by their habit of indiscriminate oviposition in cages, often under conditions not conducive to maturation of the eggs; by the refusal of the larvae to feed or by their cannibalistic voracity, which also hinders rearing en masse; by mortality resulting from physiological disorders during ecdysis and pupation and by disease organisms throughout development; and by the inhibitory effect of cage retention upon reproductive behavior. To complicate this research dilemma, the study of many species has tended to divide the disciplinary research effort, and as a result, confused the interpretation of efforts with individual species.

In conjunction with our studies of feeding behavior and reproductive physiology, rearing attempts of several species of Coastal Plain Tabanidae were begun in 1977. Initial work with summer tabanids at inland locations was greatly restricted by very small populations of nearly all species, even the most abundant and successful dominants. On the other hand, populations of several species inhabiting marshes along the Gulf of Mexico were apparently unaffected by the factors reducing populations of the inland forms.

The Coastal Marsh Fauna

Inland from the barrier beaches and estuaries of the Texas coast line, are intermittently flooded tidelands inhabited by a specialized fauna of Tabanidae distinct from other faunas of the Coastal Plain found inland, and of other groups of tideland faunas found eastward. Specifically, this fauna is characterized by five species which are intimately associated with coastal marshes. *Tabanus eadsi* Philip and *T. texanus* Hine share the same range along the south Texas coast, a range extending into western Louisiana (Thompson and Pechuman, 1970). A larger, and sometimes more prominent species, numerically, is *T. acutus* (Bigot), a form occurring from West Galveston Bay, and possibly further south, eastward along the Gulf to coastal counties of the Florida Panhandle (Fairchild, 1937; Stone, 1938). The distribution of *T. lineola* var. *hinellus* Philip, of *T. nigrovittatus* Macquart and of their related forms extends eastward along the Gulf Coast, and then northward along the Atlantic Coast (Philip, 1965).

A survey of marshes on the south Texas coast line in 1971 by Thompson (1973) characterized this ecosystem and the tabanid populations then inhabiting it, by presenting the relative abundance and seasonal ranges of the species comprising the fauna; by providing population indices for dominant and subdominant species throughout the season; and by describing the traps used in collecting the insects and in accumulating the data. A concomitant study published soon thereafter (Thompson and Gregg, 1974) described the trap modifications necessary under the rigorous coastal weather conditions; and discussed the relative efficiency of the 2 trap types used. More significantly, this work greatly simplified the objectives of the present study.

Methods and Results

Changes in the fauna.—Initial trap collections on 18 July showed that the population structure of the West Bay study area had changed in the 6-year interim since the previous (1971) study (Thompson, 1973) (Table 1). Although consecutive weekly population indices from 18 July through 17 August showed that *T. nigrovittatus* still dominated the West Bay

Table 1. Relative abundance of *Tabanus* spp. taken in five consecutive weeks during late July and early August, 1971 and 1977, West Bay.

	Percent of Population			
Species	1971		1977	
T. nigrovittatus Macquart[a]	88.5		74.0	
T. lineola var. *hinellus* Philip	1.5		21.1	
T. sulcifrons Macquart	5.6		0	
T. acutus (Bigot)	0.3		3.7	
T. subsimilis subsimilis Bellardi	1.7		0.2	
T. texanus Hine	1.0		0.1	
Remaining species[b]	1.4	(7 spp.)	0.9	(2 spp.)
Total percent	100.0		100.0	
Total flies	4,724		1,660	

[a] Sens. lat., i.e., nominal *T. nigrovittatus* and *T. nigrovittatus* var. *fulvilineis* Philip were not differentiated for the purposes of this study because of the large number of intermediate specimens observed here.

[b] Species found only in 1971: *Tabanus atratus* F., *T. cymatophorus* Osten Sacken, *T. eadsi* Philip, *T. mularis* Stone, and *T. stygius* Say; in both years, *Tabanus lineola lineola* F. and *Chrysops flavidus* Wiedemann.

marshes during the summer months, 2 coastal marsh species, *T. acutus* and *T. lineola* var. *hinellus*, markedly increased. In addition, inland forms drastically declined or disappeared. No specimens of *T. sulcifrons* were taken although 265 females had been trapped in 1971. Five other inland species represented by 1–10 specimens during the same period in 1971 were not taken in 1977 (q.v., footnote "b", Table 1). These differences become more meaningful considering that the 1977 catches were augmented with CO_2. (The harsh winter temperatures which probably decimated inland populations of these same species, could also have affected those at West Bay.)

Trap characteristics.—Five weekly collections, usually on several consecutive days in each week, were made from 18 July through 17 August. In order to collect large numbers of *Tabanus nigrovittatus* et al., several traps of 2 types were operated in areas previously shown to be productive (Thompson, 1973). The modified Manitoba Trap (MT) and modified Animal Trap (AT) were improved for use under the windy, open and sunlighted conditions of the marsh. In order to reduce heat within the collection containers of the traps and thereby to reduce fly mortality and to enable feeding by the flies held within them, the top walls or ceilings of the containers were replaced by ¼ in.-mesh hardware cloth.

Previous trapping experience with the coastal marsh species at West Bay in 1971 indicated that the AT was more collective than the MT (i.e., it collected more species in larger numbers). Also to advantage, the larger size of the collection cage easily accommodated the many flies required by the work. Finally, the AT collection container made a more suitable cage for permanent retention of the flies in the laboratory, both because of the dimensions and because of the nontoxic nature of the construction materials (the styrene of MT collection containers is known to show insect toxicity).

Artificial feeding in the field.—Flies were fed in the field immediately after they entered the traps, or soon thereafter, with whole beef blood treated with sodium citrate (10 g/gal). This blood was offered to the insects using animal membranes manufactured from lamb intestine; although this material is commercially available in sheets, using the material in the form of prophylactics allowed the membranes to be used as containers for the blood. Fourex Natural Skins[1] (Schmid Laboratories, Inc., Little Falls, New York 07424) were each filled with 30 ml of citrated beef blood and then closed with an overhand knot near the open end. This quantity of blood was more than ample to feed many flies and also expose a large surface of the prophylactic across the screened ceiling of the collection container. In the field, the blood was warmed on the hot radiator of the vehicle which transported the collector between trap sites.

Before the blood-filled prophylactics were placed on the top of the AT collection cage, the cage was enveloped by a corrugated cardboard box which contained a rectangular opening, 3 in. × 8 in., centered in the ceiling of the box. This opening was intended to serve the same function as the aperture beneath the collection cage in the top of the trap frame—to concentrate the insects by using a positive response to light. Then, when trapped female flies moved to the screened cage surface beneath the opening in the cardboard box, the prophylactics were placed above them on the top of the cage.

Feeding periodicity and optimal time of collection.—Mariculturists working shrimp ponds in the study area offered valuable suggestions on the feeding periodicity of tabanids in the marshes. Considering the primary objective of the work at the time—the collection of avid flies in large numbers, rather than the collection of data on diurnal rhythms—their suggestions were most helpful. These men described predawn attacks by annoying numbers of flies; the men had attempted, then, to avoid the summer sun through an early work day. As we soon discovered, the magnitude of feeding attacks and trap catches from before dawn to mid-morning, substantiated their reports and greatly enhanced the efficiency of the work.

The short periods of intense biting activity were most efficiently utilized by feeding each cage of flies after the cage was taken off the trap frame. In this manner, flies were being trapped continuously without interruption.

(Activity at dusk increased over that at mid-day but did not become as intense as that at sunrise.) After removal of each AT cage, the opening in the bottom of the cage—a funnel-shaped baffle made of cellulose acetate—was sealed with wadded tissue paper, and the cage was transported to the lab within an insulated picnic chest having convenient dimensions for this purpose (Thermos Cooler No. 7719[1]; King-Seeley Thermos Co., Norwich, Connecticut 06360). The insulating capacity of these containers was adequate for safe retention of the flies below critically high temperatures, and the insects could be returned to the laboratory in darkness, thereby preventing stress during transport.

Initial handling of the catch.—After collection and return of the catch, flies were knocked down by chilling them in a refrigerator freezer compartment for 10 min. or by anesthesia with N_2. The former method proved more effective for the large cages being used. Knock-down enabled identification, and subsequent separation by species, in order to collect data useful in subsequent trapping and to determine which species were accepting blood and which species laid what eggs. After definitive determination of egg masses later became possible (Thompson and Holmes, 1979), trapped insects were maintained in their respective AT cages until they died.

Feeding success.—During early collections, flies were examined for the presence of blood after anesthesia and identification. At this time, the abdominal segments of heavily engorged specimens were distended and rounded and the brownish integument became blackish. In some specimens not feeding to repletion, the reddish coloration of fresh blood could be recognized in the middle of the abdomen by shining the light from a microscope lamp through it. Additional study of females which were apparently unengorged, showed the presence of blood that was not detected by gross examination or by light transmission; this blood was observed on the tip of a straight pin which was used to puncture the hindgut through the posterior abdominal segments of dead females. Table 2 shows the results of initial (field) feeding by three coastal marsh species taken in collections of three dates.

Engorgement and mortality.—Feeding ratios were observed in three catches but the mortality of engorged vs. unengorged insects was not recorded because of more pressing priorities at the time. Nevertheless, the large percentages of engorged females which failed to survive feeding, transportation, or anesthesia seemed unusual.

Laboratory maintenance of adults.—Flies were initially retained in half-pint ice cream cartons in order to encourage feeding on blood-filled prophylactics and to confine them in a chamber where light intensity and temperature could be controlled. Later, flies were held in cages in the

Table 2. Percentages of *Tabanus* females feeding after collection, three samples, West Bay, 1977.[a]

Species	19 July		26 July		18 Aug.		Totals Fed (+)
	+	–	+	–	+	–	
T. nigrovittatus Macquart[b]	4	2	4	3	1	19	9 (27.3%)
T. lineola var. *hinellus* Philip	18	22	38	72	47	63	103 (39.6%)

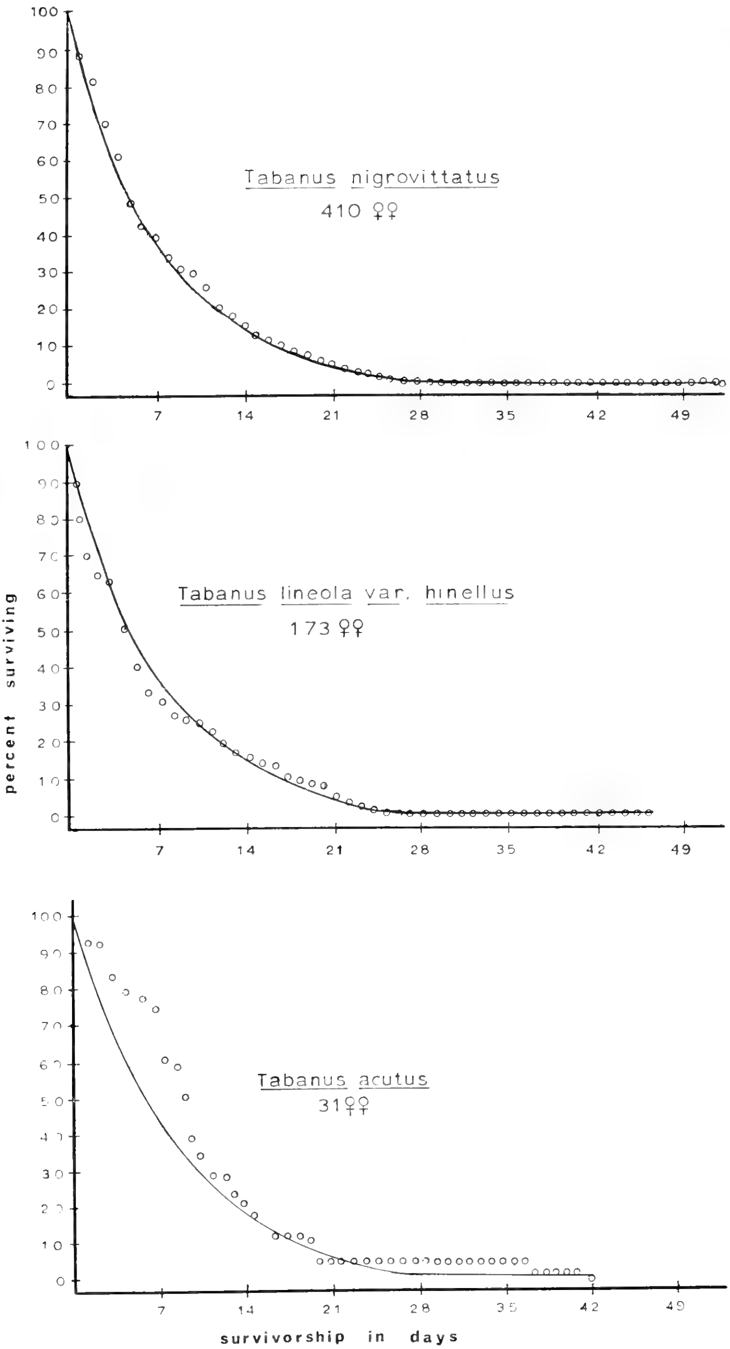
[a] Sixteen of 60 *T. acutus* females (26.7%) taken 9 August fed.

[b] Punch test with a pin showed that an additional 12 females taken on 18 August had fed.

lab when females failed to oviposit in cartons and when the control of light and temperature no longer seemed necessary to feeding or to oviposition. In addition, catches were no longer being anesthetized for identification so that transfer to smaller cages was unnecessary. At this time, then, specimens were retained in AT cages on benches in the lab. Ambient light from two large windows in one wall determined the natural photoperiod of the season. Thermometers and hygrothermographs operated in the lab throughout this period recorded temperatures of 75°F ± 5 and RH of 65% ± 5, respectively. To provide any additional moisture required, 4 in. × 4 in. cotton gauze pads placed atop the cages were continuously saturated with distilled water from an inverted pint Mason Jar above them. Only on rare occasions was a fly observed on or near this surface; therefore, ambient humidity in the room, humidity which was determined in great part by the season, was adequate under the conditions observed here.

A 10% sucrose (cane sugar) solution was provided continuously and blood was offered daily, using the technique previously described, except that prophylactics of blood were heated by immersing them in containers of warm water.

Longevity.—Under the conditions described above, survivorship of specimens taken in one sample is shown in Fig. 1. This figure shows that the rate of mortality was fairly constant at all age levels for the three species considered. This curve corresponds to Slobodkin's Type III curve (Slobodkin, 1962), a plot line becoming straight when the ordinate scale is logarithmic. The relative regularities of the graph lines for these three species reflect, in great part, the corresponding sizes of the sample populations; with *Tabanus nigrovittatus*, a species represented by 410 specimens in this sample, the mortality rate was more constant than with the less numerous species.


Tabanus nigrovittatus
410 ♀♀
Tabanus lineola var. hinellus
173 ♀♀
Tabanus acutus
31 ♀♀
percent surviving
survivorship in days
0
10
20
30
40
50
60
70
80
90
100
7
14
21
28
35
42
49

Conclusions

The techniques and materials used here for collecting, feeding and maintaining *Tabanus nigrovittatus*, *T. lineola* var. *hinellus* and *T. acutus* will enable further research in rearing these species. Many references considering collection devices for these and other coastal marsh species of eastern North America have been cited by Axtell (1976). Bearing collecting methodology in mind, the present work and that conducted 6 years before (Thompson, 1973), show that the AT and the MT are highly effective for attracting and trapping *T. nigrovittatus* in large numbers. The efficiency of collecting methods for the less numerous species considered here, such as the potential of the MT for taking *T. lineola* var. *hinellus* (Thompson and Gregg, 1974), needs further research.

Feeding of many species of Tabanidae on a great variety of vertebrate hosts has been attempted primarily in conjunction with animal disease transmission experiments. These studies, exhaustively reviewed by Krinsky (1976), have usually dealt with small numbers of insects—numbers necessary only to effect the transfer of pathogens from carriers to a small number of uninfected susceptibles. Because of this priority, rather than the engorgement of large numbers of flies intended for egg production, these studies offer little quantitative information on feeding methods and host acceptance. Moreover, fundamental studies of the basic biology of some species, studies dealing with engorgement and oviposition per se, such as those of Hafez et al. (1970), Jones and Anthony (1964), Roberts (1966), Schwardt (1936), Singh (1967), Webb and Wells (1924) and Wilson (1967), have not offered much insight into the relevant factors which stimulate feeding under conditions of retention and confinement. Also, these studies reported poor feeding results or did not present quantitative information on the numbers of flies exposed to the hosts or the percentages of those numbers feeding. In addition, papers reporting prominent success with artificial methods are very rare. Hafez et al. (1970) noted that *Tabanus taeniola* Palisot de Beauvois females, in contrast to other Egyptian species, fed to repletion on citrated calf blood. During studies of blood meal volume and digestive enzymes, Thomas and Gooding (1976) noted that several species of *Chrysops* and *Hybomitra* accepted warmed defibrinated beef blood through Silverlight membranes.

Results with beef blood-filled prophylactics used in this study were markedly negative or positive. Approximately 25–50 adult females of

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Fig. 1. Survivorship of three coastal marsh tabanids, taken at West Galveston Bay, July and August, 1977.

Tabanus fuscicostatus Hine, *T. lineola lineola*, *T. melanocerus* Wiedemann, *T. proximus* Walker, *T. subsimilis subsimilis* and *T. sulcifrons* each rejected this combination while the same numbers, or more, of *T. mularis*, *T. abactor* Philip and the three coastal marsh species considered here, readily accepted it. In most instances, the insects had come to traps baited with dry ice; and at least some individuals of each of these species were offered blood-filled prophylactics on the tops of trap collection containers very soon after being taken. These data, as well as those of Thomas and Gooding (1976), suggest membranes hold potential success in feeding this group of Diptera, as they have for tsetse species and mosquitoes. On the other hand, results with free blood could be much less favorable; none of the species that we exposed to citrated beef blood on cotton, including *Hybomitra lasiophthalma*, fed.

In studies of the longevity of several hundred caged *Tabanus nigrovittatus* females in the laboratory in Delaware, Olkowski (1966) expressed survivorship in "mean fly days" (12.3 days for *T. nigrovittatus*). Comparing his data with ours is not very meaningful because he excluded 43% of his population sample because these females survived less than 6 days. Secondly, he presents no expression of variation in this population.

In any event, the survivorship that we observed in this the present work, as the collecting and feeding results that we also experienced, will enable study of further consecutive events in the life histories of these species.

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Veterinary Toxicology and Entomology Research Laboratory, Fed. Res., Sci. and Educ. Admin., USDA, College Station, Texas 77840.

Footnote

[1] This paper reports the results of research only. Mention of a commercial or proprietary product does not constitute a recommendation for use by the U.S. Department of Agriculture.

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THE GENUS *TYCHIUS* GERMAR (COLEOPTERA: CURCULIONIDAE): LARVAE AND PUPAE OF SOME SPECIES, WITH EVALUATION OF THEIR CHARACTERS IN PHYLOGENETIC ANALYSIS[1]

Wayne E. Clark, Horace R. Burke and Donald M. Anderson

Abstract.—Larvae of eight species and pupae of five species of North American *Tychius* are described. Of these, only the larvae of *T. picirostris* (Fabricius) and *T. stephensi* Schönherr, have been previously described. Larvae of the European *T. quinquepunctatus* (L.) and *T. flavicollis* Stephens, also described, are compared to larvae of the North American species and to other European species known from previously published descriptions. Larval and pupal characters appear to support some groupings previously postulated on the basis of morphological characters of adults and host plant relationships. However, because of the lack of structural complexity in known characters of *Tychius* immatures, and the apparent lack of major differences between many of the species in these stages, it appears that the larval and pupal characters do not provide strong evidence of phylogenetic relationships. Superficial similarity due to parallelism or convergence appears likely in some cases. The hypothesis of polyphyly of the genus *Miccotrogus* Schönherr is not refuted by characters of the immature stages of some of the species formerly assigned to that taxon.

Since revision of the North American species of *Tychius* (Clark, 1971), the senior author has continued studies of members of that genus and of the related genus *Sibinia*. A classification of the subfamily Tychiinae (Clark et al., 1977), including the genera *Tychius* and *Sibinia*, provides a framework for research on the group. Relationships of North American *Tychius* to members of the much larger Old World, primarily Palearctic, *Tychius* fauna are discussed by Clark (1976, 1977). A revised classification of native North American *Tychius* and host and distributional records for these are also included in the 1977 paper. Clark and Burke (1977) present notes on life histories and habits of native North American *Tychius* and review biology of world members of the genus which consists of more than 300 nominate species, several of which are of economic importance (see Muka, 1954; Hoffmann et al., 1963; Yunus and Johansen, 1967; Nasredinov, 1975). Similar information on members of the genus *Sibinia* is presented by Clark (1978a).

Most published descriptions and illustrations of immature stages of members of the genus *Tychius* are not sufficiently detailed to be taxonomically useful. Exceptions are those of *T. quinquepunctatus* (L.) by Grandi (1916) and Scherf (1960), and *T. flavus* Becker by Servadei (1947). Scherf (1964) also assembled information from numerous sources on bionomics and immature stages of Curculionoidea, including several species of *Tychius*, of Central Europe. These and other publications (see Burke and Anderson, 1976) have been searched for taxonomic characters of *Tychius* larvae and pupae, and these characters are compared with the ones revealed by our own observations. In this paper we describe larvae of 6 of the 12 known native North American species of *Tychius* and pupae of 4 of these, larvae of 2 European species introduced into North America and the pupa of one of these, and larvae of 2 other European members of the genus. The usefulness of the larval and pupal characters described in recognizing monophyletic groups within the genus has also been analyzed.

Materials and Methods

As Ahmad and Burke (1972) and Burke and Anderson (1976) pointed out, systematic studies of immature Curculionidae, as well as of other Coleoptera, have not progressed as rapidly as studies based on adults. This is due in part to the relative difficulty encountered in obtaining specimens of the immature forms and the more time-consuming procedures necessary to prepare larvae for study. Timing is the critical factor in obtaining *Tychius* larvae and pupae. Larvae suitable for taxonomic study are available for only a short period when fruits of their hosts, members of the legume subfamily Papilionoideae, are mature. Once infested fruits are found, however, larvae may be obtained relatively easily by placing the pods in porcelain pans. When larvae emerge from infested pods they may be transferred to a mixture of sand and peat moss in widemouth glass jars. The larvae tunnel into the substrate, pupate and complete their development to the adult stage there (see Clark and Burke, 1977).

Larvae of 8 and pupae of 5 of the 14 species of *Tychius* known to occur in North America have been collected. Larvae and pupae were preserved in 70% ethyl alcohol; a few reared adults were also preserved with the immatures to facilitate subsequent identification. When larvae were collected but pupae and adults were not subsequently reared, identification was based upon association with adults taken on plants from which the larvae were obtained.

Larvae of some species were obtained for study through loans from the Ohio State University (OSU), the U.S. National Museum (USNM), and from Dr. C. A. Johansen, Washington State University (collections are referred to in the text by the abbreviations in parentheses); specimens collected by Clark are deposited in the collections of the Department of

Entomology, Texas A&M University (TAM) and in the USNM. For some of the borrowed material, larvae and pupae were identified by association with accompanying adults, even when there was no direct evidence that the adults were reared from larvae from the same lot. When no adults were present, reliance was placed upon determination labels with the immatures, even though there was usually no indication as to how these determinations were made.

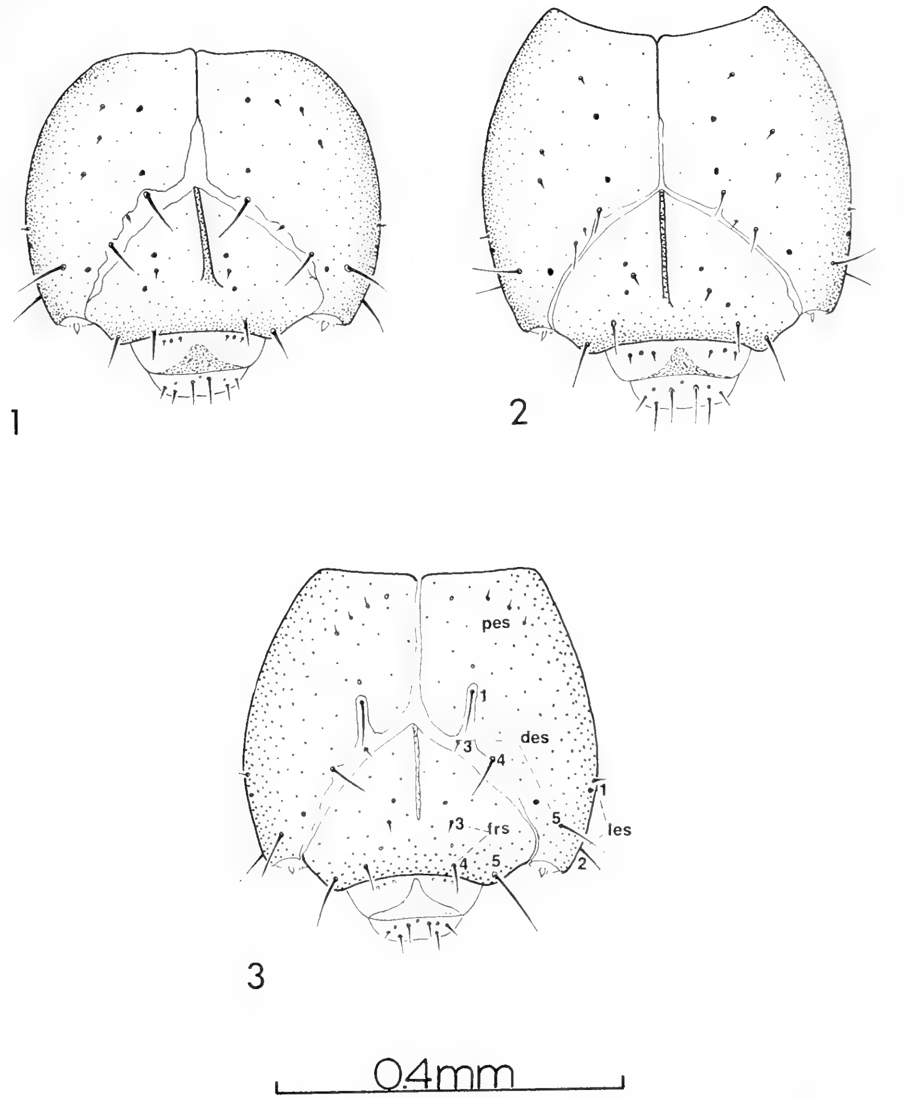
Pupae and entire larvae were examined in alcohol, but examination of most larval characters required that the specimens be slide-mounted. Except for a few modifications, slides were prepared by the procedures described by Ahmad and Burke (1972). It was found to be easier to remove the mouthparts from the head capsule before removing the latter from the body. Mounting and examination were also easier when the 2 sides of the larval skin remained broadly intact mid-dorsally than when the two halves were completely separated. Hoyer's was used as the mounting medium. Drawings were made by procedures outlined by Ahmad and Burke (1972).

Anderson (1947) is followed for terminology of larval characters. Where applicable, pupal terminology proposed by Burke (1968) is used. In the text the setae on only 1 side of the body are described.

Descriptions

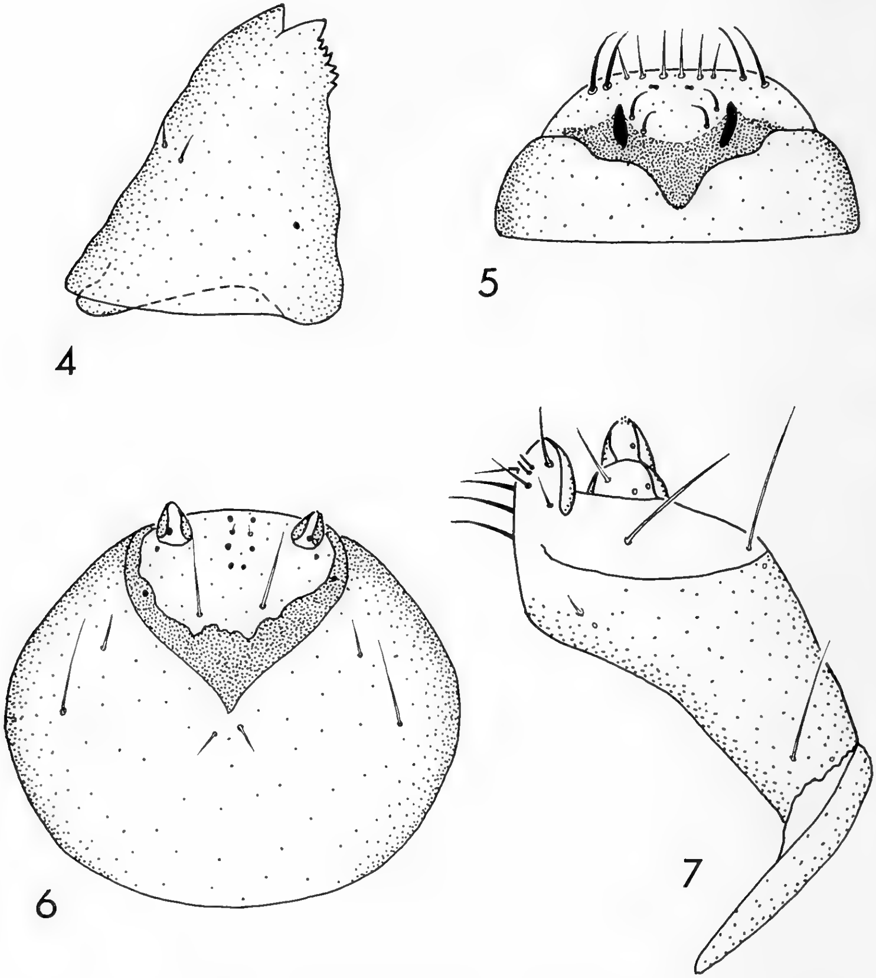
Genus *Tychius* Germar

Larva.—Body (Fig. 8): Elongate, slightly curved; integument rugulose in large species, smooth in smaller ones; larger species with transverse rows of fine asperities on ventral portions of thoracic and 1st few abdominal segments. Head (Figs. 1–7): Free, wider than long, narrowed slightly anteriorly; anterior ocelli present. Antenna with membranous basal article bearing a blunt to elongate, acute accessory appendage and several minute sensory processes. Hypopharyngeal bracon distinct. Frontal sutures distinct throughout length, incomplete anteriorly. Epicranial suture less than ½ as long as head capsule. Frons bearing 3 pairs of setae, setae 1 and 2 absent, seta 3 short to minute, seta 4 long, but shorter than seta 5; 2 pairs of frontal sensilla, 1 pair between frontal setae 3 and 4, the other anterior, lateral, or posterior to seta 3. Dorsal epicranial seta 1 minute or long, setae 4 and 5 long, seta 3 short, located on or slightly posterior to frontal suture between setae 1 and 4, seta 2 absent; 1 sensillum located between dorsal epicranial setae 4 and 5 on each side, another just posterior to seta 1. Lateral epicranium with 2 pairs of setae, seta 1 short, seta 2 longer; 1 pair of sensilla located anterior to seta 1. Ventral epicranium with 2 pairs of short setae. Posterior epicranium with 2 or 3 pairs of minute setae and 2 pairs of



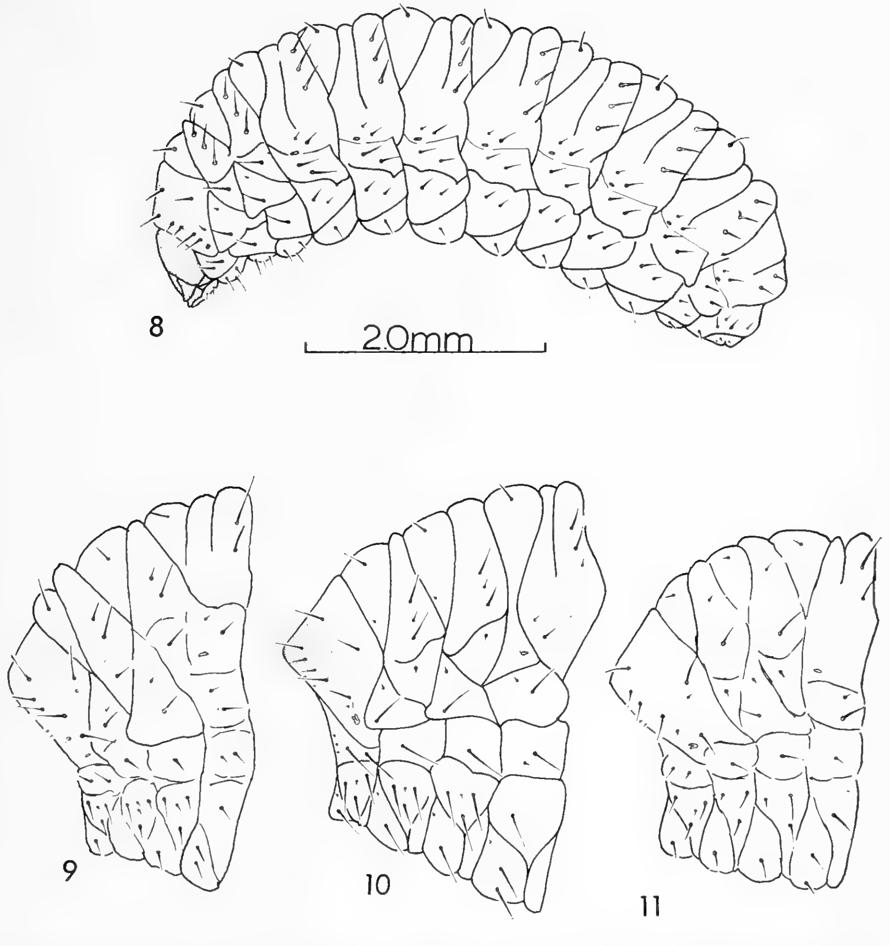
Figs. 1–3. Dorsal views of head capsules of larval *Tychius*. 1, *T. sordidus*. 2, *T. lineellus*. 3, *T. quinquepunctatus*.

sensilla. Clypeus wider than long, with 2 pairs of minute setae and 2 sensilla, each 1 of which is located between or slightly distad of clypeal setae on each side. Labrum (Figs. 1–3) with 3 pairs of setae, seta 3 shorter than seta 2; labral sensilla present, median labral sensillum present or absent. Epipharynx (Fig. 5) with 2 anterolateral setae on each side, 6



Figs. 4–7. Mouth parts of *Tychius sordidus*. 4, Left mandible, dorsal view. 5, Epipharynx. 6, Labium, ventral view. 7, Right maxilla, ventral view.

anteromedian setae, and 4 medium spines; 2 pairs of epipharyngeal sensilla present. Labral rods short, stout, widely separated. Mandible (Fig. 4) with 2 apical teeth, 2 mandibular setae and 1 sensillum. Maxillary palpus (Fig. 7) consists of 2 articles; apical article with 1 sensillum and an apical cluster of minute papillae; basal article shorter than apical article, bearing 1 seta, 2 sensilla. Labium (Fig. 6), palpus consists of 1 article; premental sclerite with anterior and posterior median extensions obsolete; prementum



Figs. 8–11. Lateral views of larval *Tychius*. 8, *T. sordidus*. 9, *T. stephensi* (thoracic and 1st adbominal segments). 10, *T. tectus* (thoracic and 1st abdominal segments). 11, *T. tectus* (thoracic and 1st abdominal segments).

with 1 pair of long setae and 1 pair of sensilla; glossa with 1 or 2 pairs of short to minute setae and 2 or 3 pairs of medial sensilla, and 1 sensillum located near base of each labial palpus; postmentum with 2 or 3 pairs of setae, seta 1 short or absent, seta 2 long, seta 3 shorter than 2. Thorax (Figs. 8–11): Not narrower than abdomen. Pronotum with 7–8 minute to long setae and 2 minute setae on anterolateral margins. Thoracic spiracle unicameral or bicameral. Prodorsum and epipleural lobe of mesothorax and metathorax each with 1 long seta. Pleural area of prothorax with 2

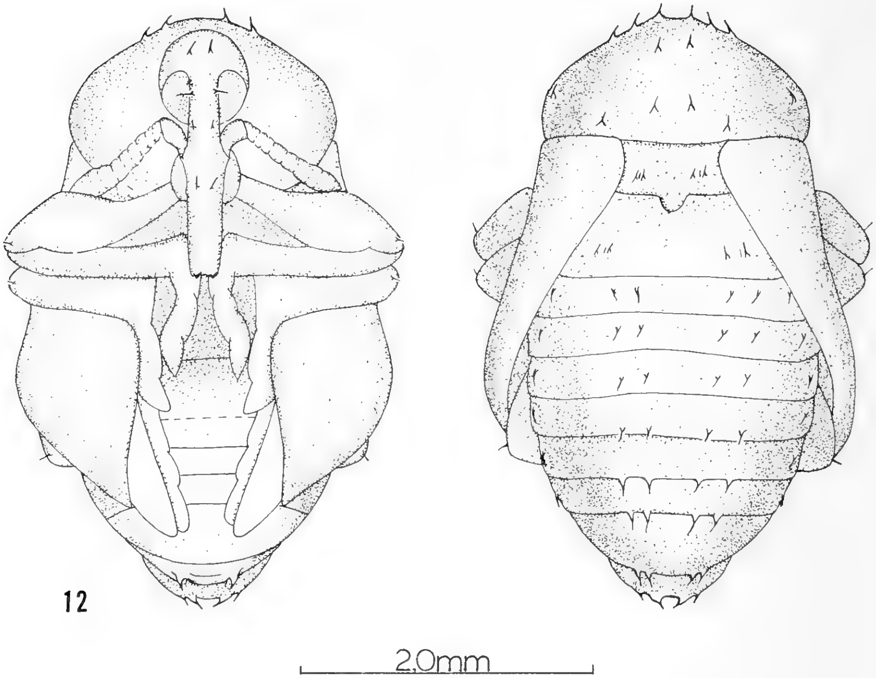


Fig. 12. Pupa of *Tychius sordidus*, ventral view on left, dorsal view on right.

long setae, and with 3 minute setae on extreme anteromedian margin; pleural area of mesothorax and metathorax each with 1 long seta. Sternum of each thoracic segment with 1 moderately long seta and 1 minute seta. Abdomen (Figs. 8–11): 8 pairs of lateral, unicameral spiracles. Segments I-VII each with 3 dorsal folds, prodorsal fold more prominent than postdorsal; segment VIII with 2 dorsal folds. Segments I-VII each with 1 long prodorsal seta and 2–3 postdorsal setae. Epipleurum with 1 long and 1 shorter seta. Pleural area with 1 long and 1 shorter seta. Pedal areas each with 1 long seta. Eusternum with 2 long setae. Segment IX with 1 postdorsal seta, 1 short and 1 longer epipleural setae, 1 short and 1 longer pleural setae and 1 short and 1 longer eusternal setae. Sternellum distinct. Anus terminal, anal folds bearing a few minute setae.

Pupa (Fig. 12).—Head: Distirostral setae absent. Two pairs of basirostral setae, 1 pair located just distad of ocular area, the other directly over the point of antennal insertions, proximal pair usually longer than distal pair, each borne on summit of rounded to conical tubercle. One pair of interorbital setae, each seta borne on summit of conical tubercle; interorbitals longer and stouter than basirostrals. Supraorbital setae absent. One or

2 pairs of frontal setae present, each seta borne on summit of conical tubercle; frontals about same length as interorbitals. Pronotum: 1 pair of anteromedian setae; 2 pairs of anterolateral setae; 1 pair of discal setae located directly posterior to anteromedian setae, sometimes more widely separated than anteromedians; 1 pair of posteromedian setae, and 1 or 2 pairs of posterolateral setae. Mesonotum and Metanotum: Anteronotal setae absent. One to 3 pairs of posteronotal setae; when 2 or more pairs present, setae on each side close together, borne on separate tubercles or on common tubercle; 3rd seta when present not borne on tubercle. Abdomen: Anterotergal setae absent. One to 3 pairs of discotergal setae, each seta borne on summit of conical tubercle, tubercles becoming larger posteriorly. One pair of laterotergal setae on terga 1–7 or 8, each seta borne on summit of low, indistinct tubercle. Segment 9 with a pair of short, sharply pointed, widely separated posterior processes. Abdomen devoid of ventral setae. Femora: Bearing 1 or 2 setae, or without setae; when only 1 seta present it is borne on outer face near apex, 2nd seta if present borne on dorsal surface near apex.

Material examined.—The larval description is based upon examination of larvae of *T. sordidus* LeConte, *T. lineellus* LeConte, *T. tectus* LeConte, *T. semisquamosus* LeConte, *T. soltaui* Casey, *T. prolixus* Casey, *T. quinquepunctatus*, *T. stephensi* Schönherr, *T. picirostris* (Fabricius) and *T. flavicollis* Stephens, and published descriptions of *T. flavus* (Servadei, 1947; Scherf, 1964), *T. meliloti* Stephens, and *T. crassirostris* Kirsch (Scherf, 1964). The pupal description is based on examination of pupae of *T. sordidus*, *T. tectus*, *T. soltaui*, *T. prolixus* and *T. picirostris* and on published descriptions of *T. quinquepunctatus* (Scherf, 1964), *T. flavus* (Servadei, 1947; Scherf, 1964) and *T. meliloti* and *T. crassirostris* (Scherf, 1964).

Discussion.—Known *Tychius* larvae are distinguished from larvae of *Sibinia sulcatula* (Casey) (Rogers et al., 1975), and *S. sodalis* Germar (Scherf, 1964), by the following combination of characters: Dorsal epicranial seta 1 long (except *T. picirostris*); dorsal epicranial seta 3 short, located on or slightly posterior to frontal suture between dorsal epicranial setae 1 and 4; epipharynx with 2 instead of 3 sensory pores; mandible with 2 rather than 3 apical teeth; abdominal prodorsal seta long; spiracular seta 2 long. Known pupae of *Tychius* members can be distinguished from the pupa of *S. sulcatula* by the number of posterolateral pronotal setae; 1 or 2 in *Tychius*, 4 in *S. sulcatula*. Scherf's (1964) description of the pupa of *S. sodalis* does not clearly indicate the number of posterolateral setae.

The larvae and pupae of the species listed above under the material examined heading are each described below; characters cited in the generic description are omitted. The diagnostic characters of the larvae are listed in Table 1, those of the pupae in Table 2.

Table 1. Summary of selected larval characters showing distribution among some species of *Tychius.*

Larval Character States		*sordidus*	*lineellus*	*tectus*	*semisquamosus*	*soltaui*	*prolixus*	*quinquepunctatus*	*flavicollis*	*stephensi*	*picirostris*	*flavus*	*meliloti*
Dorsal epicranial seta 1	short										X		
	long	X	X	X	X	X	X	X	X	X		X	
Median labral sensillum	present	X	X	X	X	X	X	X	X	X		X	
	absent										X		
Dorsal malar setae	3									X	X		
	4	X	X	X	X	X	X	X	X				
Sensilla labial palpus	1	X		X	X	X	X	X	X				
	2		X							X	X		
Pairs glossal setae	1	X	X	X	X	X	X		X				
	2							X		X	X		
Long pronotal setae	5	X	X	X	X	X	X	X	X				
	4									X	X	X	
Thoracic spiracle	unicameral									X		X	X
	bicameral	X	X	X	X	X	X	X	X		X		
Thoracic postdorsal setae	2									X	X	X	
	3	X	X	X	X	X	X	X	X				
Alar setae	short		X	X	X	X	X	X	X	X	X		
	long	X											
Epipleural seta 2	short		X	X	X	X	X	X	X	X	X		
	long	X											
Pleural setae	1										X		
	2	X	X	X	X	X	X	X	X	X			

Tychius sordidus LeConte
Figs. 1, 4–8, 12

Tychius sordidus LeConte, 1876:217.

Larva.—Body: 4.6–6.6 mm long (40 larvae); shining, yellow. Head (Fig. 1): Uniformly dark yellowish brown; truncate posteriorly; width of

Table 2. Summary of selected pupal characters showing distribution among some species of *Tychius*.

Pupal Character States		*sordidus*	*tectus*	*soltaui*	*prolixus*	*quinque-punctatus*	*flavicollis*	*stephensi*	*picirostris*	*flavus*	*meliloti*	*crassirostris*
Anterolateral setae of pronotum (pairs)	2	X	X	X	X	X			X			
	3									?	?	?
Posterolateral setae of pronotum (pairs)	1								X		?	
	2	X	X	X	X	X						
Posteronotal setae of pronotum (pairs)	1					X			X			
	1–2	X	X	X	X							
Discotergal setae of abdomen (pairs)	1		X	X	X	X			X			X
	2	X									?	
Femoral setae	1	X		X					O	X		X
	2		X		X	X						

head capsule 0.82–0.94 mm (8 larvae). Ocellar areas lacking subcutaneous pigment. Accessory appendage of antenna robust, sides rounded. Endocarina more than ½ as long as frons. Dorsal epicranial seta 1 long. Median labral sensillum present. Malar area of maxilla (Fig. 7) with 5 ventral and 4 dorsal setae. Labial palpus (Fig. 6) with 1 sensillum; glossa with 1 pair of minute setae; postmental seta 1 present. Thorax (Fig. 8): Pronotum with 5 long setae, 2 moderately long setae, 1 short seta and 2 minute anterolateral setae. Spiracle bicameral, air tubes each with 5 to 8 annuli. Postdorsum of mesothorax and of metathorax each with 3 long setae. Pedal area of each thoracic segment with 3 long and 3 minute to moderately long setae. Sternal seta slightly shorter than ventralmost pedal seta of the same segment. Abdomen (Fig. 8): Postdorsum with 3 long setae of subequal length. Spiracular seta 1 long, seta 2 shorter. Epipleural seta 1 slightly shorter than seta 2. Pleural seta 2 slightly shorter than seta 1.

Pupa (Fig. 12).—Length: 3.9–5.0 mm (25 pupae). Head: Distalmost pair of basirostral setae absent in some specimens. Pronotum: 2 pairs of posterolateral setae. Mesonotum and Metanotum: 1–3 pairs of posteronotal setae. Abdomen: 2 pairs of discotergal setae on terga 1–5; terga 6 and 7 often each with 3 pairs of setae, tergum 8 usually with 1 pair, but sometimes with 2 pairs of discotergals. Legs: Femur with 1 seta or without a seta.

Material examined.—Fifty larvae (40 entire, 10 slide-mounted specimens, TAM, USNM), which emerged from pods of *Baptisia leucophaea* Nutt. var. *laevicollis* (Gray) Small, collected 10 May 1973, at College Station, Brazos County, Texas, and 25 pupae (TAM, USNM), laboratory reared from larvae from the same pods, all determined by association with reared adults.

Discussion.—*Tychius sordidus* occurs in the eastern and midwestern United States. Its known hosts are all members of the plant genus *Baptisia* (Clark, 1971; Clark and Burke, 1977). The larva is distinguished from that of other members of the genus by the following combination: Alar area of each thoracic segment with 1 long seta; mesothorax and metathorax each with 3 long postdorsal setae of subequal length. The pupa is distinguished as follows: Femoral setae 1 or none; posteronotal setae 1–3 pairs; discotergal setae 2 pairs.

Tychius lineellus LeConte
Fig. 2

Tychius lineellus LeConte, 1876:217.

Larva.—Body: 5.7–6.8 mm long (3 larvae); opaque, pale yellowish white. Head (Fig. 2): Uniformly dark brown; emarginate posteriorly; width of head capsule 0.74–0.84 mm (5 larvae). Ocellar areas with subcutaneous pigment. Accessory appendage of antenna moderately long, sides slightly rounded. Endocarina more than ½ as long as frons. Dorsal epicranial seta 1 long. Labral setae 1 and 2 subequal in length. Median labral sensillum present. Malar area of maxilla with 5 ventral and 4 dorsal setae and 1 ventral sensillum. Labial palpus with 2 sensilla; glossa with 1 pair of minute setae; postmental seta 1 present. Thorax: Pronotum with 5 long setae, 2 shorter setae and 1 minute seta, in addition to 2 minute anterolateral setae. Spiracle bicameral, air tubes with 5 to 8 annuli. Postdorsum of mesothorax and of metathorax with 3 setae, seta 3 long, seta 2 very short, seta 1 intermediate in length. Pedal area of each thoracic segment with 3 long and 3 minute to moderately long setae and a few sensilla. Sternal seta slightly shorter than ventral-most pedal seta of the same segment. Abdomen: Postdorsum with 3 setae, setae 1 and 3 slightly shorter than seta 2. Spiracular seta 1 long, seta 2 slightly shorter. Epipleural seta 1 slightly shorter than seta 2. Pleural seta 2 slightly shorter than seta 1.

Pupa.—Unknown.

Material examined.—Eight larvae (3 entire, 5 slide-mounted specimens, TAM, USNM), which emerged from pods of *Lupinus leucophyllus* Dougl., collected 6 July 1968, 5 miles east of Springville, Utah County, Utah, determined by association with adults collected on the plants.

Discussion.—*Tychius lineellus* occurs in the western United States and adjacent portions of Canada. Its known hosts are members of the plant genus *Lupinus* (Clark, 1971). The larva is distinguished from larvae of other species of *Tychius* by the following combination: Labial palpus with 2 sensilla; mesothorax and metathorax each bearing 3 setae, setae 1 and 2 short, seta 3 long. It also has a sensillum on the malar area of the maxillary palpus, as does the Old World *T. quinquepunctatus*. Adult characters do not indicate a close relationship between *T. lineellus* and *T. quinquepunctatus*, however.

Tychius tectus LeConte
Fig. 10

Tychius tectus LeConte, 1876:217.
Tychius mixtus Hatch, 1971:355.

Larva.—As described for *T. sordidus*, except as follows. Body: 5.5–5.8 mm long (8 larvae); pale yellowish white to yellow. Head: Uniformly light yellowish brown; posteriorly truncate; width of head capsule 0.60–0.67 mm (4 larvae). Ocellar areas lacking subcutaneous pigment. Accessory appendage of antenna short, sides rounded. Endocarina distinct, more than ½ length of frons. Dorsal epicranial seta 1 long. Labral seta 1 longer than seta 2. Median labral sensillum present. Malar area of maxilla with 5 ventral and 4 dorsal setae. Labial palpus with 1 sensillum; postmental seta 1 present. Thorax (Fig. 10): pronotum with 5 long setae, 2 moderately long setae, and 1 minute seta, in addition to 2 minute anterolateral setae. Spiracle bicameral, air tubes with 4 to 6 annuli. Postdorsum of mesothorax and of metathorax with 3 setae; setae 1 and 3 long, seta 2 minute. Pedal area of each thoracic segment with 3 long setae, 1 short to minute seta, and 1 sensillum. Sternal seta long, subequal in length to ventral-most seta of pedal area of same segment. Abdomen (Fig. 10): Postdorsum with 3 setae, setae 1 and 2 longer than seta 3. Spiracular seta 1 long, seta 2 very short. Epipleural seta 1 much shorter than seta 2. Pleural seta 2 much shorter than seta 1.

Pupa.—The pupa of *T. tectus* differs from that of *T. sordidus* in its smaller size (length 2.9–3.4 mm) and by possession of the lowermost pair of basirostral setae, 2 femoral setae, 1 or 2 pairs of mesonotal and metanotal posteronotal setae and 1 pair of discotergal setae on terga 1–8.

Material examined.—Twelve larvae (8 entire, 4 slide-mounted specimens, TAM, USNM), from pods of *Astragalus distortus* var *engelmanii* (Sheldon) Jones, collected 5 May 1972, at College Station, Brazos County, Texas and 3 pupae (TAM, USNM), laboratory-reared from other larvae taken from the same plants at the same time, all determined by association with reared adults.

Discussion.—*Tychius tectus* is widely distributed throughout the Great

Plains and Rocky Mountain regions of the western United States and adjacent portions of Canada (Clark, 1971 and 1977). Its hosts, members of the papilionoid tribe Astragaleae, include species of *Astragalus* in primarily Eurasian groups, members of the same genus in autochthonous American groups, and species of *Oxytropis,* a primarily Eurasian genus closely related to *Astragalus* (Clark, 1977). The larva is distinguished from larvae of other members of the genus as follows: Mesothorax and metathorax each with 3 postdorsal setae, setae 1 and 3 long, seta 2 short; typical abdominal segments also with 3 postdorsal setae, setae 1 and 2 long, seta 3 short. Distinguishing characters of the pupa are listed above.

The larvae and pupae of most of the other American Astragaleae-associated *Tychius* are either apparently identical to those of *T. tectus,* or are distinguished only by minor, in some cases variable characters (these are enumerated in the discussions of *T. semisquamosus, T. soltaui* and *T. prolixus,* which follow). The close similarity of these species to each other supports the contention that the Astragaleae-associated *Tychius* form a monophyletic (possibly paraphyletic) group (Clark, 1977).

Tychius semisquamosus LeConte

Tychius semisquamosus LeConte, 1876:217.
Tychius lamellosus Casey, 1892:418.
Tychius squamosus Hatch, 1971:356.
Tychius intermixtus Hatch, 1971: 356.

Larva.—The larva of *T. semisquamosus* has subcutaneous pigment on the ocellar areas and fine asperities on the thoracic and abdominal sterna but cannot otherwise be distinguished from that of *T. tectus.*

Pupa.—Unknown.

Material examined.—Sixteen larvae (12 entire, 4 slide-mounted specimens, TAM, USNM), from pods of *Astragalus beckwithii* T. & G., collected 1 June 1972, 2.5 miles southeast of Provo, Utah County, Utah, determined by association with adults collected on the plants.

Discussion.—Tychius semisquamosus occurs in the Rocky Mountain region of the western United States and adjacent portions of Canada, and in southern California (Clark, 1971 and 1977). Its known hosts are all species of *Astragalus* in native American groups (Clark, 1977).

Tychius soltaui Casey

Tychius soltaui Casey, 1892:416.
Tychius hirsutus Clark, 1971:30 (replacement name for *T. hirtellus* LeConte, 1876:218; not Tournier, 1873).

Larva.—The larva of *T. soltaui* is indistinguishable from that of *T. tectus*, except for possession of subcutaneous pigment on the ocellar areas. It is distinguished from the larva of *T. semisquamosus* only by the lack of conspicuous asperities on the thoracic and abdominal sterna.

Pupa.—The pupa of *T. soltaui* differs from that of *T. tectus* by having 1 instead of 2 femoral setae.

Material examined.—Thirty-one larvae (20 entire, 11 slide-mounted specimens, TAM, USNM), which emerged from pods of *Astragalus nuttallianus* A., D.C., collected 10 April 1973, 0.7 miles southeast of San Diego, Duval County, Texas, and from pods of *A. emoryanus* (Rydb.) Cory, collected 31 May 1973, 35 miles south of Alpine, Brewster County, Texas, determined by association with reared adults.

Discussion.—*Tychius soltaui* occurs in the western United States and adjacent portions of Canada (Clark, 1971) and in the state of Durango, Mexico (Clark, 1977). Its known hosts are species of *Astragalus* in native American groups (Clark, 1977). The relationship of *T. soltaui* to the other American species of *Tychius* associated with *Astragalus* was considered in the discussion of *T. tectus*.

Tychius prolixus Casey

Tychius prolixus Casey, 1892:419.

Larva.—The larva of *T. prolixus* is indistinguishable from that of *T. tectus*. It is distinguished from larvae of *T. semisquamosus* and *T. soltaui* by the absence of subcutaneous pigment from the ocellar areas.

Pupa.—The pupa of *T. proxilus* differs from that of *T. tectus* only in possession of 2 instead of 1 pair of meso- and metathoracic posteronotal setae. Some of the specimens examined have 1, but most have 2 femoral setae, as in *T. tectus*.

Material examined.—Twenty-one larvae (11 entire, 10 slide-mounted specimens, TAM, USNM), which emerged from pods of *Astragalus utahensis* (Torr.) T. & G., collected 1 June 1972, at the mouth of Rock Canyon, northeast of Provo, Utah County, Utah, and from pods of *A. wootonii* Sheldon, collected 30 May 1973, 6.5 miles east of the junction of Highways 505 and 166, Jeff Davis County, Texas, and 15 pupae (TAM, USNM), reared from larvae from the *A. utahensis* lot, all determined by association with reared adults.

Discussion.—*Tychius prolixus* occurs in southern California, Nevada, Utah, Arizona and western Texas (Clark, 1971). Its known hosts are species of *Astragalus* which belong to native American groups (Clark, 1977). Significance of characters by which *T. prolixus* and other *Astragalus*-

associated species are distinguished from each other was considered in the discussion of *T. tectus*.

Tychius quinquepunctatus L.
Fig. 3

Curculio 5-punctatus L. 1758:383.
Tychius 5-punctatus Germar, 1817:340.

Larva.—Body: 4.8–6.5 mm long (8 larvae); shining, yellow. Head (Fig. 3): Uniformly dark brown; rounded posteriorly; width of head capsule 1.23–1.30 mm (2 larvae). Anterior ocellar areas with minute spot, or without subcutaneous pigment. Accessory appendage of antenna robust. Endocarina more than ½ as long as frons. Dorsal epicranial seta 1 long, located well posterior to frontal suture. Posterior epicranium with 3 pairs of minute setae. Median labral sensillum present. Malar area of maxilla with 5 ventral setae, 4 dorsal setae, and 1 ventral sensillum. Labial palpus with 1 sensillum; glossa with 2 pairs of minute setae; postmental seta 1 present. Thorax: Pronotum with 5 long setae, 2 shorter setae, and 1 minute seta in addition to 2 minute anterolateral setae. Spiracle bicameral. Postdorsum of mesothorax and of metathorax each with 3 setae, of which seta 1 is long, seta 2 shorter, seta 3 longer than 1. Pedal area of each thoracic segment with 3 long and 2 short setae. Sternal seta long, subequal in length to ventral-most pedal seta of same segment. Abdomen: postdorsum with 3 long setae of subequal length. Spiracular seta 1 long, seta 2 shorter. Epipleural seta 1 longer than seta 2. Pleural seta 1 longer than seta 2.

Pupa (from Scherf, 1964, Fig. 238).—Length: 5–5.3 mm. Head: 2 pairs of frontal setae. Pronotum: Anterior-most pair of anterolateral setae located beside anteromedian setae, 2nd pair displaced posteriorly, behind subapical constriction of pronotum; 2 pairs of posterolateral setae present. Mesonotum and Metanotum: each with only 1 pair of posteronotal setae. Abdomen: Terga 1–8 each with 1 pair of discotergal setae. Legs: Femora each with 2 setae.

Material examined.—Ten larvae (8 entire, 2 slide-mounted specimens, USNM), labeled "*Tychius quinquepunctatus*, 209, Erlangen Rosenhauer," were examined. Identity of these specimens cannot be verified as there are no associated adults.

Discussion.—This European species reportedly has hosts in the papilionoid genera *Lathyrus*, *Phaseolus*, *Pisum* and *Vicia* (Scherf, 1964). The larva is distinguished from larvae of other known species of *Tychius* by the following combination: Glossa with 2 pairs of minute setae; malar area of maxilla with a ventral sensillum; postdorsum of mesothorax and of metathorax with 3 setae, seta 1 long, seta 2 short, seta 3 longer than 1. The pupa has 2 femoral setae, 1 pair each of mesonotal and metanotal setae, and terga each with 1 pair of discotergal setae.

Larvae and pupae of *T. quinquepunctatus* have more in common with larvae and pupae of *T. sordidus*, *T. lineellus*, and the *Astragaleae*-associated species (*T. semisquamosus*, *T. tectus*, *T. soltaui* and *T. prolixus*) than with those of the clover seed weevils (*T. stephensi* and *T. picirostris*) and that of *T. flavus* (Table 1). The only other species of *Tychius* known to have a sensillum on the malar area of the larval maxilla is *T. lineellus*; *T. picirostris* is the only other known species with only 1 pair of mesonotal setae. Adult characters do not indicate that *T. quinquepunctatus* is closely related to either of these, however, and it is likely that both similarities are due to convergence.

? *Tychius flavicollis* Stephens

Tychius flavicollis Stephens, 1831:56.

Larva.—As described for *T. tectus*, except as follows. Body: White. Head: Width of head capsule 0.52 mm (1 larva); rounded posteriorly. Endocarina ⅔ length of frons. Dorsal epicranial seta 1 long, located posteriorly distant from frontal suture. Mandibular setae long. Thorax: pronotum with 5 long setae and 3 short setae, in addition to 2 minute anterolateral setae. Pedal area of prothorax with 3 long and 2 short setae; pedal areas of mesothorax and metathorax each with 3 long setae and 3 short setae. Abdomen: Postdorsum with 3 setae, setae 1 and 3 short, seta 2 long.

Pupa.—Unknown.

Material examined.—Two larvae (1 entire, 1 slide-mounted specimen), labelled Schonebeck, a.d. Elbe 21-8-1931, C. Urban, (USNM) were examined.

Discussion.—No adults are associated with the specimens described here, so their identity is questionable. The specimens were apparently transmitted to the USNM from Urban, their collector. Urban (1935) reported finding larvae of *T. flavicollis*, along with larvae of *T. meliloti*, in the fruit of *Melilotus alba* Lam. Perris (1877), however, cited by Hoffman (1954) and Scherf (1964), stated that larvae of *T. flavicollis* develop in seeds of *Lotus corniculatus* L. Lengerken (1941) stated that *T. meliloti* develops in galls on the leaves of *Melilotus macrorhiza* Pers., and Hoffmann (1954) adds *M. alba* and *M. officinalis* (L.) to the list of hosts of that species.

There is indirect evidence that the larva described above as *T. flavicollis* is not that of a Trifolieae-associated species, and is therefore possibly correctly associated with the species Franz (1942) called *T. flavicollis*. Franz considered *T. flavicollis* to be related to *T. kulzeri* Penecke, *T. cinnamomeus* Kiesenwetter and *T. cretaceus* Kiesenwetter. *Tychius cretaceus* was listed as synonym of *T. cinnamomeus* by Hoffmann (1954) who listed *Dorycnium suffruticosus* Vill. as the host of the weevil. The genera *Dorycnium* and *Lotus* belong to the papilionoid tribe Loteae (Hutchinson, 1964). Since closely related species of *Tychius* usually have closely related hosts, it is likely that Franz's *T. flavicollis* is a species associated with the plant genus *Lotus*. The tribes Loteae and Trifolieae are considered to be closely related (Hutchinson, 1964). Adult characters, however, indicate that *T. flavicollis* is also closely allied to the Trifolieae-associated *Tychius* (specimens of *T. flavicollis* as well as specimens of Trifolieae-associated species determined by Franz himself have been examined). The larva described above, however, shows greater affinity to larvae of Astragaleae-associated *Tychius*, than to those of the Trifolieae-associated *T. picirostris*, *T. stephensi* and *T. flavus* (see discussions of these below). Clark (1977) noted that *T. flavicollis* resembles the American Astragaleae-associated *T. liljebladi* Blatchley.

Tychius stephensi Schönherr
Fig. 9

Curculio picirostris Fabricius, 1787:101.
Curculio tomentosus Herbst, 1795:278 (not Olivier, 1790:536).
Tychius stepheni Schönherr, 1836:412.
Tychius stephensi Schönherr. Stephens, 1839:229.

Larva.—As described for *T. tectus*, except as follows. Body: 2.74–3.59 mm long (8 larvae); opaque, white. Head: Width of head capsule 0.41–0.48 mm (5 larvae). Ocellar areas with subcutaneous pigment. Dorsal epicranial seta 1 long. Clypeal setae moderately long. Median labral sensillum present. Malar area of maxilla with 5 ventral setae and 3 dorsal setae. Labial palpus with 2 sensilla; glossa with 2 pairs of minute setae. Thorax (Fig. 9): Pronotum with 4 long setae, 2 slightly shorter setae and 2 minute setae, in addition to 2 minute anterolateral setae. Spiracle unicameral, air tube with 4 or 5 annuli. Postdorsum of mesothorax and of metathorax with 2 setae, seta 1 moderately long, seta 2 longer. Pedal area of each thoracic segment with 3 long setae. Abdomen (Fig. 9): Postdorsum with 2 setae, seta 1 long, seta 2 shorter. Pleuron with 1 long and 1 short seta.

Pupa.—Unknown.

Material examined.—Six slide-mounted and numerous whole specimens labelled "Minnesota, St. Paul, 25 June, 1948, A. Peterson, ex heads red clover" (OSU), determined by association with adults preserved with larvae, were examined. These are the specimens upon which Peterson (1951) based his description of the larva of *T. stephensi*.

Discussion.—Introduced from Europe into North America, *T. stephensi* develops in the fruit of red clover, *Trifolium pratense* L. It is known as the red clover seed weevil in America. Although it has been called *T. stephensi* (sometimes *T. stepheni*) in America, in Europe it is known as *T. tomentosus* Herbst. As Clark (1971) pointed out, neither name is strictly correct since the types of both are conspecific with the type of *Curculio picirostris* Fabricius, 1787. Schönherr (1825) misidentified Fabricius' *C. picirostris* and applied the name *picirostris* to the species commonly known in Europe and America as *Miccotrogus picirostris*. Since *Miccotrogus* is now in synonymy with *Tychius*, the appropriate combination is *Tychius picirostris* (Fabricius), following Clark (1976). A proposal to the International Commission on Zoological Nomenclature suggesting a solution is in preparation.

The larva of *T. stephensi* is distinguished from the other known *Tychius* larvae as follows: Thoracic spiracle unicameral, postdorsum of mesothorax and of metathorax, as well as of each abdominal segment, with 2 setae. The larva of *T. picirostris* is distinguished from that of *T. stephensi* by the bicameral thoracic spiracle, absence of the median labral sensillum, the short dorsal epicranial seta 1, possession of a single pleural seta on the abdominal segments, only 2 long pleural setae on the mesothorax and metathorax, and generally shorter thoracic and abdominal setae throughout.

Larvae of at least 2 other species of *Tychius* with hosts in the papilionoid tribe Trifolieae, *T. flavus* and *T. meliloti*, also have unicameral thoracic spiracles. The larvae of these do not differ from the larva of *T. stephensi* in any known characters. If the close resemblance of the larvae of the Astragaleae-associated species described above to each other is any indication of the way closely allied species of *Tychius* may be expected to differ, the larvae of *T. stephensi*, *T. flavus* and *T. meliloti* may in fact be difficult, if not impossible, to distinguish. Larvae of all 3 of these also have in common with *T. picirostris* most observed characters, including several (2 sensilla on labial palpus, 4 long pronotal setae, 2 thoracic and abdominal postdorsal setae and 3 dorsal setae on malar area of maxilla) not shared by the other known *Tychius* larvae. These shared characters support the contention that the Trifolieae-associated *Tychius* form a monophyletic group. Some of the members of this group, including *T. picirostris*, were formerly assigned to *Miccotrogus* (see Clark, 1976).

Tychius picirostris (Fabricius)
Fig. 11

Miccotrogus picirostris (Fabricius). Schönherr, 1825:583, and subsequent authors, based on misidentification of *Curculio picirostris* (Fabricius, 1787).

Tychius picirostris (Fabricius). Clark, 1976.

Larva.—As described for *T. tectus*, except as follows. Body: 1.78–2.81 mm long (8 larvae); opaque, white. Head: Width of head capsule 0.43–0.44 mm (2 larvae). Ocellar areas with subcutaneous pigment. Dorsal epicranial seta 1 minute. Clypeal setae minute. Median labral sensillum absent. Malar area of maxilla with 5 ventral setae and 3 dorsal setae. Labial palpus with 2 sensilla; glossa with 2 pairs of setae, without sensilla. Thorax (Fig. 11): Pronotum with 4 long setae, 2 slightly shorter setae, and 2 minute setae, in addition to 2 minute anterolateral setae. Spiracle bicameral, air tubes of unequal length. Postdorsum of mesothorax and of metathorax with 2 setae, seta 1 short, seta 2 longer. Pedal areas of mesothorax and of metathorax with 2 long setae and 1 shorter seta. Abdomen (Fig. 11): Postdorsum with 2 setae, seta 1 long, seta 2 short. Pleuron with 1 moderately long seta.

Pupa.—Length: 1.14–1.28 mm. Head: 2 pairs of frontal setae, 1 pair small, each seta borne on small tubercle located slightly anterior and mesal to larger pair of tubercles which bear much stouter, longer setae. Pronotum: Anterior-most pair of anterolateral setae located beside anteromedian setae, 2nd pair displaced posteriorly to apical ¼ of pronotum; 1 pair of posterolateral setae. Posteromedian setae more widely separated than discal setae. Abdomen: Terga 1–8 each with 1 pair of discotergal setae. Legs: Devoid of setae.

Material examined.—Ten larvae (8 entire, 2 slide-mounted specimens TAM, USNM) and 3 pupae (TAM, USNM) collected in eastern Washington or western Idaho, by Yunus and Johansen, determined (by Johansen) by association with adults reared from white clover seeds, were examined.

Discussion.—This European species, like *T. stephensi*, has been introduced into North America where it is a pest of clover seed. It is called the clover seed weevil. Its biology was studied by Yunus and Johansen (1967). Hosts in North America are white clover, *Trifolium repens* L., and alsike clover, *T. hybridum* L. Problems of the nomenclature of this species and the red clover seed weevil are reviewed above in the discussion of *T. stephensi.*

The larva of *T. picirostris* is distinguished from the other known *Tychius* larvae as follows: Thoracic spiracle bicameral; median labral sensillum and glossal sensilla absent; and pedal area of mesothorax and of metathorax each bearing 2 long setae and 1 shorter seta. The pupa is distinguished by possession of 1 pair of posterolateral pronotal setae, 2 pairs of posteronotal setae on the meso- and metathorax, 2 pairs of discotergal setae on the abdomen, and absence of femoral setae.

Comparisons of the larva of *T. picirostris* and of the related *T. stephensi*, *T. flavus* and *T. meliloti* and hypotheses concerning relationships of these to each other and to other *Tychius* are set forth above in the discussion of *T. stephensi.*

Tychius flavus Becker

Tychius flavus Becker, 1864:488.

Larva.—Servadei (1947) provided fairly good illustrations and description of the larva of *T. flavus*, from which the following diagnosis is taken: Length 2.5–3.0 mm; head brown, endocarina ½ as long as frons; dorsal epicranial seta 1 long; median labral sensillum present; malar area of maxilla with 3 ventral setae, and 9 (?) dorsal setae; postmental seta 1 present; pronotum with 6 long setae (this probably indicates 4 long and 2 slightly shorter setae); all spiracles unicameral; postdorsum of mesothorax and that of metathorax with 2 setae; pedal area of each thoracic segment with 3 long setae; postdorsum of typical abdominal segments each with 2 setae.

Scherf's (1964) description and illustrations of the larva of *T. flavus* are apparently adapted from those of Servadei (1947). These are not as complete as those of Servadei, however, and some inconsistencies are noted. For example, Scherf illustrated an extra frontal seta, and omitted the median labral sensillum. Servadei's description and illustrations are more in line with our observations on members of the genus *Tychius.* Unfortunately, neither Scherf's nor Servadei's descriptions are complete enough to permit some important comparison (e.g. relative setal lengths, number of sensilla on the labial palpae and glossa).

Pupa.—Scherf (1964, Fig. 244) also reproduced Servadei's (1947) illustration of the pupa of *T. flavus* (which unfortunately included only a ventral view) and gave a brief description. From these the following diagnosis is derived: Length 2.0–2.5 mm; rostrum devoid of setae; 1 pair of frontal setae present, interocular and supraocular setae absent; apparently 3 pairs of anterolateral pronotal setae present; legs each with 2 femoral setae.

The identity of the specimens examined by Scherf and Servadei has not been verified.

Discussion.—This European species develops in pods of *Medicago sativa* L. (Scherf, 1964). It is a serious pest of seed production of this important forage crop in Europe. Its biology was studied by Tanasijevic (1955) and by Ionescu et al. (1965).

The only character mentioned by Servadei (1947) by which the larva of *T. flavus* differs from the larvae of the other *Tychius* with unicameral thoracic spiracles (*T. picirostris* and *T. meliloti*) is the number of ventral setae on the malar area of the maxillary palpus, which Servadei (1947:159, Fig. XVII) depicted as no fewer than 9; we observed not more than 5 ventral malar setae in the species examined. Servadei's (1947) description of the pupa is too brief to be of value in making comparisons.

Tychius meliloti Stephens

Tychius meliloti Stephens, 1831:55.

Larva.—Scherf (1964) provided a brief description, without illustration, of the larva of *T. meliloti.* This agrees with our generic description but, aside from showing that the thoracic spiracles are unicameral, it is not of further taxonomic value.

Pupa.—Scherf's (1964) description of the pupa of *T. meliloti* omits important diagnostic characters but does indicate that it has the following: Length 2.5–2.8 mm; rostrum with 1 pair of basirostral setae and 1 pair of interocular setae; head with 1 pair of frontal setae; pronotum with 6 pairs of setae; abdomen apparently with 2 pairs of discotergal setae. No mention is made of femoral setae.

Discussion.—Urban (1935) reported that this European species develops in fruit of *Melilotus alba* and *M. officinalis.* Scherf (1964) also listed *M. altissimus* as a host.

The unicameral larval thoracic spiracle and the host association indicate that *T. meliloti* is closely allied to 2 of the other Trifolieae-associated species, *T. stephensi* and *T. flavus*, as considered in the discussion of *T. stephensi.* The pupa is apparently like that of *T. picirostris* in possessing only a single pair of posterolateral pronotal setae.

Tychius crassirostris Kirsch

Tychius crassirostris Kirsch, 1871:48.

Larva.—Mik (1885) and Scherf (1964) presented brief descriptions and illustrations of the larva of *T. crassirostris.* These agree with our generic description, but do not contain information diagnostic at the species level.

Pupa.—Mik (1885) illustrated a ventral view of the pupa of *T. crassirostris.* Scherf (1964) reproduced the figure and from it wrote a brief description. According to Scherf the pupa is 2.8–3.4 mm long. The figure indicates that the setae on the head are as illustrated for *T. sordidus*

(Fig. 12), except that the lowermost basirostral seta is actually "distirostral" in position. One pair of frontal seta are present. The pronotum apparently has 3 pairs of anterolateral setae, the abdomen only a single pair of discotergal setae. The legs each bear 1 femoral seta.

Discussion.—Mik (1885) and Urban (1935) give accounts of the life history and habits of this European species whose larvae develop in galls on the leaves of *Melilotus alba.* Scherf (1964) lists other *Melilotus* as well as *Medicago* hosts.

The larva of *T. crassirostris* is poorly known. The pupa is evidently like those of *T. flavus* and *T. meliloti* in possessing 3 pairs of anterolateral pronotal setae, and like that of *T. picirostris* in having only a single pair of posterolateral pronotal setae.

Taxonomic Relationships

Although only a small proportion of the total number of species of *Tychius* (13 out of more than 300) are known from the immature stages, some general statements concerning taxonomic relationships based on characters of these stages can be made. Characters of the larvae and pupae of some species appear to support some groupings indicated by adults and host plant relationships. A comprehensive evaluation of character states of the adults for recognition of monophyletic groups in *Tychius* has yet to be carried out, however; and we have not attempted to determine relative apomorphy–plesiomorphy in the characters of the relatively small sample of immatures studied.

Distributions of character states of larvae and pupae diagnostic at species level in *Tychius* are presented in Tables 1 and 2, respectively. Diagnostic characters for larvae include differences in relative lengths of setae on the head capsule, thorax and abdomen, presence or absence of setae and sensilla on the mouthparts, and numbers of chambers in the thoracic spiracles. Presence or absence of pigment on the ocellar areas, and presence or absence of asperities on the sternal areas of the thoracic and abdominal segments also appear to distinguish some species, but others exhibit variation in these features. Pupae of species of *Tychius* differ from each other in numbers of pairs of anterolateral and posterolateral pronotal setae, mesonotal and metanotal setae, discotergal abdominal setae, and in presence or absence and numbers of femoral setae. Some of these pupal characters are variable within the small samples examined.

Trifolieae-associated species.—The most distinctive grouping indicated by larval characters includes *T. stephensi*, *T. picirostris*, *T. flavus* and *T. meliloti*, all of which have hosts in the papilionoid tribe Trifolieae (*Trifolium*, *Melilotus* and *Medicago*). The existence of a monophyletic Trifolieae-associated group within the genus *Tychius* was postulated by

Clark (1976). The known larvae of members of this group are distinguished as follows: Malar area of maxillary palpus with 3 dorsal setae; labial palpus with 2 sensilla; glossa of labium with 2 pairs of setae; pronotum with 4 long setae; mesothorax and metathorax each with 2 postdorsal setae. Some of these character states are shared by other *Tychius* larvae, but none have them in the same combination. Only 1 Trifolieae-associated species, *T. picirostris*, is known in sufficient detail in the pupal stage to permit meaningful comparisons. The pupa of this species, and apparently that of *T. meliloti*, are distinguished from other *Tychius* pupae by possession of only 1 pair of posterolateral pronotal setae.

The larva of *T. picirostris* differs from known larvae of other Trifolieae-associated *Tychius* in the short dorsal epicranial seta 1, absence of the medial labral sensillum and short abdominal pleural seta 1. It is also unique among Trifolieae-associated species in possession of bicameral thoracic spiracles, a feature which it shares with all known non-Trifolieae-associated *Tychius* larvae.

Tychius flavicollis.—Adult characters and host relationships indicate that the other *Tychius* whose immature stages are known represent at least 5 different infrageneric groups (see Clark, 1976 and 1977). These groups are more homogeneous in the immature stages than the Trifolieae-associated group, however (Tables 1 and 2). The adult of *T. flavicollis* resembles adults of Trifolieae-associated species, but it also resembles some adults of a group of species associated with members of the papilionoid tribe Astragaleae, most notably the American *T. liljebladi* (see Clark, 1977). The larva of *T. flavicollis*, however, does not differ from larvae of Astragaleae-associated species in any of the characters studied (the pupa is unknown). The host of *T. flavicollis*, *Lotus corniculatus*, belongs to Loteae, a papilionoid tribe which Hutchinson (1964) considered to be more closely related to Trifolieae than to Astragaleae.

Tychius quinquepunctatus.—On the basis of adult characters, *T. quinquepunctatus* appears to be closely allied to species assigned to the genera *Apeltarius* Desbrochers and *Xenotychius* Reitter. The larva of *T. quinquepunctatus* differs from larvae of Astragaleae-associated *Tychius* only in possession of 2 rather than 1 pair of setae on the glossa of the labium. It differs from the larvae of *T. sordidus* and *T. lineellus* only in characters which it shares with Astragaleae-associated species. It has 2 pairs of glossal setae on the labium, like Trifolieae-associated *Tychius*. The pupa of *T. quinquepunctatus* also shows affinity to Trifolieae-associated species in possession of a single pair of posterolateral pronotal setae. Characters of the adults of *T. quinquepunctatus* and of Trifolieae-associated species, however, do not indicate that the 2 groups are closely related. Known hosts of *T. quinquepunctatus* belong to the genera *Pisum* and *Vicia*, members of the tribe Vicieae, a tribe which Hutchinson (1964) considers to be closely allied to the tribe Trifolieae.

Astragaleae-associated species.—Monophyly of this group whose members occur in North America and Eurasia was postulated by Clark (1977) on the basis of adult characters and host relationships. Members of the group with known immature stages, *T. tectus*, *T. semisquamosus*, *T. soltaui* and *T. prolixus*, have nearly identical larvae. They differ from each other in presence or absence of pigment on the ocellar areas and presence or absence of asperities on the sternal areas of the thorax and abdomen. These differences are minor and of doubtful taxonomic value. The pupa of *T. soltaui* has 1 instead of 2 femoral setae, but it is otherwise indistinguishable from known pupae of other Astragaleae-associated species, which in turn are indistinguishable from each other.

Tychius lineellus and *Tychius sordidus.*—Adult characters indicate that these North American species represent 2 distinct but related species groups (Clark, 1977). Larvae of the 2 species differ in several respects. The larva of *T. lineellus* differs from all known *Tychius* larvae, except those of Trifolieae-associated species, by possessing 2 sensilla on the labial palpus. This similarity is probably the result of convergence; adult *T. lineellus* in no way resemble adults of Trifolieae-associated species, and the hosts of *T. lineellus* (species of *Lupinus*, tribe Lupineae) are not closely related to the Trifolieae. The head of the larva of *T. lineellus* (Fig. 2) also has several distinct features not listed in Table 1, namely the head capsule is deeply emarginate posteriorly, the accessory appendage of the antenna is long and slender and dorsal epicranial setae 1 and 3 are relatively short (cf. *T. sordidus* Fig. 1). In adult characters *T. lineellus* appears to be more closely allied to the European *T. venustus* (Fabricius) than to any American *Tychius* (see Clark, 1977). The larva of *T. sordidus* differs from that of *T. lineellus* and larvae of Astragaleae-associated species in the relatively long setae on the alar area of the thoracic segments and on the epipleural folds of the abdominal segments. The pupa of *T. sordidus* is unique among known *Tychius* pupae in possessing 2 pairs of discotergal setae on abdominal terga 1–8.

Status of *Miccotrogus* Schönherr.—One of the species whose immatures are described herein, *T. picirostris*, along with several other European *Tychius*, were previously assigned to a separate genus, *Miccotrogus* Schönherr, because they have 6 instead of 7 antennal funicular articles. The North American *T. prolixus*, although never formally assigned to *Miccotrogus*, also has 6 funicular articles. After examining adult morphological characters and host relationships of several Old World and American species, Clark (1976) concluded that *Miccotrogus* was polyphyletic, and he placed that name in synonymy with *Tychius*. The immatures of *T. picirostris* and of

T. prolixus have nothing in common which would justify their separation from other *Tychius* examined. We conclude, therefore, that Clark's (1976) hypothesis of polyphyly is not refuted by characters of the immatures described herein. It should be noted, however, that although immatures of *T. prolixus* differ only in minor respects from those of other Astragaleae-associated *Tychius*, the larva and pupa of *T. picirostris* are distinguished from other Trifolieae-associated *Tychius* by several features (see discussion of Trifolieae-associated species).

Conclusions

It is often claimed that characters of the immature stages of weevils and other insects should or do contribute to knowledge of phylogeny (see Emden, 1957; Ahmad and Burke, 1972; Pfaffenberger and Johnson, 1976). It is true that the immature stages provide a set of attributes which theoretically have as much potential for revealing monophyletic groups as do adult structures. Some authors have noted the lack of congruence between classifications based on characters of immatures and those based on adults (see Rohlf, 1963; Pfaffenberger and Johnson, 1976). It seems to us that any 2 systems (e.g. morphological, karyotype, behavioral, biochemical, etc.) may differ to the extent that purely phenetic classifications based on them will be incongruent. However, we feel that what is needed in systematic studies is that all systems be analysed, the evidence drawn from each synthesized into a unified system, preferably a phylogenetic one. This is the essence of Hennig's (1966) holomorphological method. The attributes of different developmental stages should be considered of equal value in phylogenetic analysis to the extent that similarities are not the results of parallelism or convergence.

We have observed larvae and pupae of several members of the subfamily Tychiinae (those treated herein, those of *Sibinia sulcatula* (Rogers et al., 1975), and of other species of *Sibinia* which will be described elsewhere, and those of *Neotylopterus pallidus* (LeConte) (Clark, 1978b), as well as immatures of members of several other subfamilies (including published accounts by Emden, 1938; 1952; Ahmad and Burke, 1972; and others listed by Burke and Anderson, 1976). For the most part, character states of these have yet to be rigorously analysed with the express intent of recognition of synapomorphies. Instead, analyses have been of the sort presented in the previous section; i.e., recognition of groups on the basis of subjectively weighted similarity. From the present study of tychiines and from our general familiarity with curculionid immatures, it is expected that the search for synapomorphy, at least at and below the generic level, will be fraught with difficulty. This is because attributes observed up to now, and upon which most studies, including the present one, are based (differences in numbers, positions and relative lengths of setae, variation in numbers of chambers in the spiracles) are, for the most part, of the sort that one worker (Schlee, 1969) referred to as "simple features poor in structure and having only a few details." It is generally agreed that with such characters it may be difficult to distinguish similarity due to common ancestry from similarity resulting from parallel or convergent development.

Nevertheless, we do not advocate abandonment of the search for synapomorphies in the larvae and pupae of tychiines and other weevils. It is quite possible that patterns and combinations of the kinds of characters examined in the present study will prove to be of greater value in determining relationships at higher levels. Other systems such as internal anatomy (see May, 1967 and 1977) are also likely to contribute useful information. Furthermore, the host and other biological information usually obtained while collecting immatures has already been shown to be of value as evidence of phylogenetic relationships in the Curculionidae.

Acknowledgments

Some of the information presented here was part of a Ph.D. dissertation submitted by the senior author to the Department of Entomology, Texas A&M University. This information was supplemented and re-evaluated by the senior author during his tenure as Post-Doctoral Fellow in the Entomology Department, Smithsonian Institution. Some of the specimens studied were provided by C. A. Triplehorn, Ohio State University, and C. A. Johansen, Washington State University. We also thank W. N. Mathis and D. R. Whitehead for reading and critiquing parts of early drafts of the manuscript.

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(WEC) c/o Department of Entomology, Smithsonian Institution, Washington, D.C. 20560 (now at Department of Zoology and Entomology, Auburn University, Auburn, Alabama 36830; (HRB) Department of Entomology, Texas A&M University, College Station, Texas 77843; and (DMA) Systematic Entomology Laboratory, Fed. Res., Sci. and Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560.

Footnote

[1] Technical contribution TA No. 14248. Department of Entomology, Texas Agricultural Experiment Station, College Station, Texas 77843.

PROC. ENTOMOL. SOC. WASH.
80(4), 1978, p. 655

NOTE

ON THE USE OF PECTINATE MAXILLARY SPINES TO SEPARATE *STENONEMA* AND *STENACRON* (EPHEMEROPTERA: HEPTAGENIIDAE)

Jensen (1974. Proc. Entomol. Soc. Wash. 76:225–228) removed the *Interpunctatum* group from *Stenonema* and described it as a new genus, *Stenacron*. His diagnosis of the new genus incorrectly states that the nymphs of *Stenacron* have "pectinate spines on the maxillae . . . which are absent in *Stenonema*." Several species of *Stenonema* also have pectinate spines on the crowns of the maxillae. For example, the nymphs of the *Stenonema terminatum* (Walsh) group possess comb-like spines (Fig. 1) very similar to those found on nymphs of *Stenacron* and *Heptagenia*. Use of this character to separate the two genera should, therefore, be discontinued.

Fig. 1. Pectinate spines on the crown of the maxilla of *Stenonema terminatum ares*.

Philip A. Lewis, *Biological Methods Branch, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.*

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NOTE

PARATROPES BILUNATA (ORTHOPTERA: BLATTIDAE): AN OUTCROSSING POLLINATOR IN A NEOTROPICAL WET FOREST CANOPY ?

Ongoing controversy and speculation surround discussions of how canopy plants outcross. Scant studies are available which show cockroaches to be pollinators (Proctor, M. and Yeo, P. 1972. *The Pollination of Flowers.* Taplinger Pub. Co., New York) and there are no observations on cockroaches as pollinators of canopy plants. I report here on such activity by *Paratropes bilunata* (Saussure and Zehntner) (identification by F. W. Fisk at Ohio State University, who holds the specimen) in an undisturbed Lowland wet forest at Finca La Selva, near Puerto Viejo, Heredia Province, Costa Rica. A new method of tree-climbing was used to gain access to the region of the canopy where the observations were made (Perry, *Biotropica,* in press).

Little is known about the biology of *P. bilunata* or the genus. Biolley (1900. IV Ortópteros recogidos en Costa Rica desde 1890 á 1900. Informe Nacional Costa Rica. Pp. 40–49.) did note that some *Paratropes* species are found inactive during the day under the leaves of certain small trees and can be confused with beetles of the family Lycidae. This confusion may be in part due to a striking coloration which is characteristic of many species in the genus, including *P. bilunata.*

At 1200 hours on 24 June 1976 a *P. bilunata* was seen walking in full sunlight 34 m above the ground on an inflorescence of *Dendropanax arboreus* (L.) Dec. & Planch. Rev. Hortic. (Araliaceae), an arboreal epiphyte within the crown of a *Dipteryx panamensis* (Pitt.) Record & Mell (Leguminosae). It flew successively to three nearby inflorescences over a period of several minutes without returning to a previously visited area. An attempt to net it failed, after which there were no new sightings for the remainder of the observation period which lasted one hour.

Subsequently, at 1030 hours, on 25 June, a *P. bilunata* was again seen visiting the same group of inflorescences. Its behavior was similar to the previous individual. This time, however, the cockroach was caught. Again, no other *P. bilunata* were seen for the duration of the observations which lasted for about an hour. Finally, at 1400 hours, on 3 July another *P. bilunata* was seen at the same location after it behaved similarly to the above.

Interestingly, no *P. bilunata* (adult or nymph) were ever seen at any place other than the inflorescences and proximal leaves of *D. arboreus,* even though numerous inflorescences of *Dipteryx* were present nearby.

The exposed condition of the anthers and stigmas of this plant allows *P. bilunata* to be a likely pollinator, of which the plant has many. More important, the behavior of *P. bilunata* together with the total absence of a resident population in the canopy area and the temporal distribution of sightings suggest that this species may range between a number of *Dendropanax* individuals and thus could be an outcrosser of this canopy epiphyte.

The total length of the pronotum and tegmina of the specimen is 25 millimeters. Two large cream-yellow spots are on the anterior lateral portion of a totally black pronotum. These spots are connected by a very narrow band along the anterior medial edge of the pronotum. The tegmina, when closed, are symmetrically colored. Starting laterally and going medially the tegmina are marked with first a reddish-brown longitudinal band, the anterior portion of which bears a cream-yellow spot. A black band is medial to this, followed by a reddish-brown axial band. Precisely how this patterning relates to the observations is not clear but since *P. bilunata* was diurnally active and visible to potential predators such as birds some significance may be found.

Donald R. Perry, *Department of Biology, University of California at Los Angeles, Los Angeles, California 90024.*

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NOTE

CEROPLASTES DENUDATUS, JUNIOR SYNONYM OF *C. RUSCI* (HOMOPTERA: COCCOIDEA: COCCIDAE)

The syntypes of *Ceroplastes denudatus* Cockerell (1893. Entomologist 26:82) from Antigua agree closely with specimens of *Ceroplastes rusci* (L.) (1758. Syst. Nat. Ed. 1:456) as currently recognized. Some syntypes of *C. denudatus* have spiracular setae in a complete marginal row between the anterior and posterior spiracular depressions on each side. Interspersed between these setae in the median part of the row are few bristlelike setae. The other syntypes, however, are similar to *C. rusci* in having two or more bristlelike setae separating the anterior and posterior spiracular setae.

According to Lindinger (1936. Entomol. Zaharb. 45:154), *C. denudatus* Green (nec Ckll) (1923. Bull. Entomol. Res. 14:88) from Madeira is equal to *C. rusci* (L.) Sign., thus implying that the *C. denudatus* Cockerell determined by Green was different from Cockerell's species. However, Green (op. cit. 94) based his determination on type-material of *C.*

denudatus. Therefore, I conclude that only one species was involved and that *C. denudatus* Cockerell is a junior synonym of *C. rusci* as currently recognized (NEW SYNONYM).

Ceroplastes rusci is distinguishable from other species of *Ceroplastes* in North America by the following morphological characters: Dorsal pores predominately bilocular, few simple or trilocular; medio-dorsal clear area present; spiracular setae bullet-shaped, confined to margin laterad of spiracular furrow, in 3 rows; antenna 6-segmented; leg with tibio-tarsal articulatory sclerosis, claw digitules of equal size.

The lectotype of *C. denudatus* here designated is a young adult female mounted from the dry, type-material and labeled as follows: Left label "Ceroplastes denudatus Ckll, Type, Antigua, Barber Coll., Ckll. Coccidae 104, 6111, from Cockerell, Jan. 3. 94"; right label "mounted from type-material, LECTOTYPE designated by S. Nakahara." Eleven adult, female paralectotypes on five slides and five first instar paralectotypes on one slide with same data; type slides and unmounted paralectotypes with same data in USNM. The original description of *C. denudatus* does not indicate the collection date. Whereas the description was published in 1893, "Jan. 3. 94" apparently represents the date the type material was received from Cockerell by the USDA.

Sueo Nakahara, *Plant Protection and Quarantine, Animal and Plant Health Inspection Service, U.S. Department of Agriculture, Beltsville, Maryland 20705.*

BOOK REVIEW

Entomofauna Cubana, Tomo III. Subclase Polyneoptera. 1976. Fernando de Zayas. 29.2 cm spine. 130 pp., 119 figs. (In Spanish.) Instituto Cubana del Libro, La Habana, Cuba. No price marked; said by Librarian, Instituto de Zoologia, Havana, in letter to reviewer, to be available in exchange for similar books.

This is a general, illustrated book that has numerous keys and summarizes well the insect groups covered. It probably will be most useful to local Cuban students, but it will be consulted generally by specialists. Volumes I and II of this series have not appeared. The groups in Vol. III comprise the Polyneoptera, so named by Martynov in 1923 and essentially accepted as an arrangement of orthopteroids (s. l.) by Rohdendorf (1961) and Bei-Bienko (1962). Included are Orthoptera (s. l.), Dermaptera, Isoptera, Plecoptera, Embioptera and Zoraptera. No Plecoptera are known from Cuba. For Zoraptera there has been an uncertain record of a wing found in Quarantine, and now de Zayas records an unidentified species collected from logs in Oriente and at the old experiment station in Santiago de las Vegas. At present, the cockroaches, earwigs, termites and embiids are represented by modern taxonomic reviews.

An index, unfortunately *without page numbers*, lists 179 species and various additional genera of orthopteroids considered as Cuban inhabitants. Coverage appears to be relatively complete. One small mantid, *Acontista cubana* from Cuba, and a beautiful black spotted yellow cricket, *Hygronemobius histrionicus* from the Isle of Pines, are described as new, the types to be deposited in the Instituto de Zoologia. Their descriptions are very sparse, but there are good habitus figures of both. In fact, illustrations are a strong feature. Of the 179 named species noted, 106 (including 11 of the 12 listed genera of earwigs) are represented by habitus figures, and there are additional figures of details. Several figures, including those of the cricket *Nemobiopsis gundlachi* Bol. and the grasshopper *Nichelius fuscopictus* Bol., are apparently the first published habitus figures of those species.

The author is a veteran Cuban entomologist and is said to have the largest private collection in Cuba. He studied in Louisiana as a young man and later consulted collections in Washington, D.C. Although he has published on Lepidoptera and other orders, Coleoptera are his chief interest. A 443-page volume on Cuban Cerambycidae, dated 1975, is an important comprehensive monograph; it is not of the current series.

Unhappily, the Polyneoptera volume is marred by misspellings and by errors in the bibliography, perhaps due to language problems with the printer and to gaps in available library sources. For instance, Walker appears as "Walter"; a work on termites by Snyder and Miller is credited to Rehn and Hebard; and Stephen C. Bruner of Cuba, Lawrence Bruner of Nebraska, and Carl Brunner von Wattenwyl of Vienna have been confused.

All in all, however, de Zayas has produced an attractive and helpful piece of work that merits much use, and I am delighted that major fruits of his long career are appearing.

Ashley B. Gurney, *Cooperating Scientist, Systematic Entomology Laboratory, Fed. Res., Sci. and Educ. Admin., USDA, c/o U.S. National Museum, Washington, D.C. 20560.*

BOOK REVIEW

Insect Flight. R. C. Rainey, editor. Royal Entomological Society of London, Symposium 7. John Wiley & Sons, New York, 287 pp. Cost: $47.00.

This volume is the product of the seventh biennial symposium of the Royal Entomological Society. The purpose of this series of symposia and their published reports, is to provide a topical summary of extant knowledge concerning aspects of entomological research. Earlier symposia have been concerned with insect polymorphism (1961), reproduction (1964), behavior (1966), abundance (1968), ultrastructure (1970) and insect/plant relationships (1973).

The text of the volume on insect flight consists of 12 contributed papers. The topics are as pertinent to insect flight as the authors are notable to insect flight research. Chapters and authors include: J. W. S. Pringle "The muscles and sense organs involved in insect flight", B. Mulloney "Control of flight and related behaviour by the central nervous systems of insects", W. Nachtigall "Wing movements and the generation of aerodynamic forces by some medium-sized insects", T. Weiss-Fogh "Energetics and aerodynamics of flapping flight: a synthesis", R. C. Rainey "Flight behaviour and features of the atmospheric environment", Elizabeth Betts "Forecasting infestations of tropical migrant pests: the Desert Locust and the African Armyworm", R. J. V. Joyce "Insect flight in relation to problems of pest control", G. W. Schaefer "Radar observations of insect flight", M. Lindauer "Foraging and homing flight of the honey-bee: some general problems of orientation", C. G. Johnson "Lability of the flight system: a context for functional adaptation", R. J. Wootton "The fossil record and insect flight", and V. B. Wigglesworth "The evolution of insect flight".

Individual contributions range from 13–42 pages, with most chapters 14–22 pages long; thus, the volume is balanced. Each chapter has its own terminal question-and-answer section developed at the symposium and its own bibliography. There are 646 references on insect flight in this volume with titles from 1974.

It is difficult to provide a comprehensive review of this work because it has multiple authorship and each author addresses a different aspect of insect flight. In this context the book appears somewhat disjointed. However, the editor has done an excellent job in minimizing the problems associated with multiple-author books and at the same time enabled the text to flow smoothly through the uniform application of words.

In short, I believe this book will be useful to anybody studying insect flight. However, because of its cost, it probably will be prohibitively expensive to purchase by the general reading audience.

Gordon Gordh, *Division of Biological Control, Department of Entomology, University of California, Riverside, California 92502.*

SOCIETY MEETINGS

849th Regular Meeting—March 2, 1978

The 849th Regular Meeting of the Entomological Society of Washington was called to order by President Sutherland at 8:00 PM on March 2, 1978, in the Ecology Theater of the National Museum of Natural History. Thirty-three members and 16 guests were present. The minutes of the February meeting were read by Joyce Utmar and were approved.

Membership chairman Utmar read for the first time the names of the following new applicants for membership:

R. M. Hendrickson, Jr., USDA, ARS, 501 S. Chapel St., Newark, Delaware.
H. Pearson Hopper, 3713 35th Street, NW, Washington, D.C.
Alvin Mark Wilson, 4221 Metzerott Rd., College Park, Maryland.

Ted Spilman suggested that the meeting announcement should indicate where the meeting is to be held. President Sutherland announced that the Washington Academy of Science will have their awards dinner on March 16th. President Sutherland reported that a committee composed of Chris Thompson, Doug Miller, Ted Spilman and Doug Sutherland will review the Society's By-laws for any needed change.

The main speaker for the evening was Mr. Arnold Mallis, Extension Entomologist, Retired, Pennsylvania State University. Mr. Mallis spoke on "Recollections of Some Western Entomologists," and told of how his interest in the biographies of American Entomologists developed. Afterwards, he discussed his recollections of professors and associates he had as a student at the University of California, Berkeley.

Notes and Exhibitions

John Neal showed a sesiid pest (*Synanthodon rhododendri*) of rhododendron shrubs that were being marketed in the area.

T. J. Spilman described the structure and function of the mandibles of larvae of *Dirrhagofarsus lewisi*, a false click beetle (Eucnemidae), as compared with those of larvae of ordinary beetles. Illustrations and models of the mandibles were also used.

John Kingsolver reported on recent difficulties in sending dead insects from France to the United States, apparently due to their interpretation of the Endangered Species Act.

The meeting was adjourned at 9:20 PM, after which pie and punch were served as refreshments.

Wayne N. Mathis, *Recording Secretary*

850th Regular Meeting—April 6, 1978

The 850th Regular Meeting of the Entomological Society of Washington was called to order by President Sutherland at 8:00 PM on April 6, 1978, in the Ecology Theater of the National Museum of Natural History. Twenty-six members and 10 guests were present. The minutes of the March meeting were read and approved.

Membership chairman Utmar read for the first time the names of the following new applicants for membership:

Ahmad Marwan Chawkat, 400 Arundel Rd., Dunkirk, Maryland
Italo Currado, Istituto di Entomologia dell'Universita, Via Guiria 15, 10126, Torino, ITALY
Kenneth L. Deahl, USDA, Vegetable Laboratory, Bldg. 004-Rm 210, Washington, D.C.
Neil J. Lamb, Military Ent. Information Service/AFPCB, Washington, D.C.
Lynda L. Richards, Insect Zoo, NHB 101, Smithsonian Institution, Washington, D.C.
Patricia A. Zungoli, 3416 Tulane Drive, Hyattsville, Maryland

Joyce Utmar announced that the annual banquet will be held at Fort Lesley McNair on Thursday, June 1st. Tickets are available.

President Sutherland introduced both speakers for the evening. The first, Mr. Tom Shortino, USDA, Insect Physiology Laboratory, Beltsville, Maryland, spoke on "Bioassay diets for insects." Mr. Shortino passed around various culture media, some with developing insects, and described techniques used in the production of insect diets. Dr. A. B. Gurney, Cooperating Scientist, Systematic Entomology Laboratory, USDA, was the second speaker. He addressed the topic of "Photographs and biographical notes of early entomologists." Dr. Gurney presented slides and provided biographical sketches of many notable entomologists, mostly from the late 19th and early 20th centuries.

Notes and Exhibitions

A. B. Gurney passed around the new common names list that was recently published by the Entomological Society of America. Our president, D. Sutherland, chaired the committee responsible for it. Dr. Gurney and others commented on the historical development and format of the list.

President Sutherland announced that the Missouri Botanical Garden will publish a listing of North American plants entitled "A provisional checklist of species for flora of North America."

Mr. Nelson Beyer of the U.S. Fish and Wildlife Service reported that his agency will be surveying the moths and butterflies of the Washington, D.C.

area for assay. He inquired if there were members within the area who would be willing to let them black-light in their yards.

The meeting adjourned at 9:54 PM, after which punch and cookies were served.

Wayne N. Mathis, *Recording Secretary*

XVI INTERNATIONAL CONGRESS OF ENTOMOLOGY

KYOTO JAPAN

August 3-9, 1980

FIRST ANNOUNCEMENT

The 16th International Congress of Entomology will be held in Kyoto the ancient capital of Japan, 3–9 August, 1980, under the sponsorship of the Science Council of Japan, the Entomological Society of Japan, the Japanese Society of Applied Entomology and Zoology and the Japan Plant Protection Association. Sessions will be held in the excellent modern facilities of the Kyoto International Conference Hall. All sessions and printed materials will be in English.

Scientific program.—The tentative program of the 16th Congress will include plenary sessions, symposia, regular sessions, poster sessions, film sessions and informal meetings. The Congress will cover the following fields of Entomology: Systematics, Morphology, Physiology, Biochemistry, Ecology and Population Dynamics, Genetics, Developmental Biology, Behavior, Agricultural and Forest Entomology, Toxicology, Pathology, Stored Product Insects, Medical and Veterinary Entomology, Sericulture, Apiculture, Biological Control, Integrated Control, Pesticide Development, Management and Regulation, Social Insects, Acarology and others.

Participation.—All participants are required to register for one of the three memberships: full member, associate member or student member. Registration forms will be provided in the Second Announcement which will be mailed in June 1979.

Social and associates programs.—An interesting social program will be proposed for all participants. Also a number of tours and local activities will be arranged for the associate members.

Exhibition.—It is planned to display scientific equipment, insect specimens, and books and periodicals on Entomology.

Travel and hotel accommodation.—Japan Travel Bureau (JTB) has been appointed as the official travel agent of the Congress. Hotel accommodation and travel within Japan will be arranged by JTB.

Notice.—Anyone wishing to participate in the Congress should send his or her name, address and field of interest (see list under *Scientific Program*) to the following address:

XVI International Congress of Entomology
c/o Kyoto International Conference Hall
Takara-ike, Sakyo-ku
Kyoto 606, Japan

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld	3.00
Both papers on cynipid galls	6.00
Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	1.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal	1.50

Memoirs of the Entomological Society of Washington

No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 1942	15.00
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 1976	11.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $15.00 per volume to non-members and $9 per volume to members of the Society.

Prices quoted are U. S. currency. Dealers are allowed a discount of 10 per cent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Custodian, Entomological Society of Washington, c/o Department of Entomology, Smithsonian Institution, Washington, D.C. 20560

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